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Dear BCT members:

Enclosed please find the Final Survey Units Project Reports Abstract for Sanitary Sewer and Storm Drain Removal Containing Naturally Occurring Radioactive Material Fill Material Conducted After March 1, 2013, Hunters Point Naval Shipyard, San Francisco, California. This document is being submitted for your records only.

If you have any questions regarding the enclosed document, please contact Mr. Chris Yantos at (619) 532-0912, or Mr. Derek Robinson at (619) 532-0951 at your earliest convenience.

Sincerely,

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Base Closure Manager
By direction of the Director

Enclosure: 1. Final Survey Units Project Reports Abstract for Sanitary Sewer and Storm Drain Removal Containing Naturally Occurring Radioactive Material Fill Material Conducted After March 1, 2013, Hunters Point Naval Shipyard, San Francisco, California, February 2015

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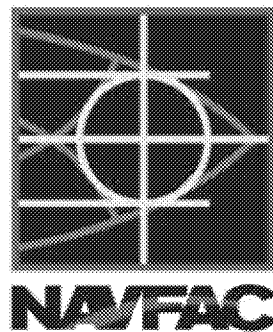
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**CONTRACT No. N62473-10-D-0809
CTO No. 0012**

FINAL

**SURVEY UNIT PROJECT REPORTS ABSTRACT FOR
PARCEL C SANITARY SEWER AND STORM DRAIN
REMOVAL CONTAINING NATURALLY OCCURING
RADIOACTIVE MATERIAL (NORM) FILL MATERIAL
CONDUCTED AFTER MARCH 1, 2013**

May 2015

DCN: RMAC-0809-0012-0052

**HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA**

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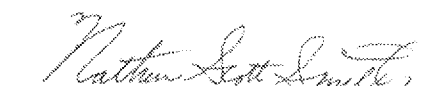
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ABBREVIATIONS AND ACRONYMS

| | |
|-------------------|---|
| $\mu\text{R/h}$ | microroentgens per hour |
| ALARA | as low as reasonably achievable |
| AM | Action Memorandum |
| ^{214}Bi | bismuth-214 |
| COC | chain of custody |
| cps | counts per second |
| ^{137}Cs | cesium-137 |
| DoD | Department of Defense |
| DON | Department of the Navy |
| DQA | data quality assessment |
| ELAP | Environmental Laboratory Accreditation Program |
| EPA | U.S. Environmental Protection Agency |
| ESU | excavated soil unit |
| FSS | Final Status Survey |
| GPS | global positioning system |
| HPNS | Hunters Point Naval Shipyard |
| HRA | Historical Radiological Assessment |
| keV | kiloelectron volt |
| LBGR | lower boundary of the gray region |
| MARSSIM | Multi-Agency Radiation Survey and Site Investigation Manual |
| MDA | minimum detectable activity |
| MDL | method detection limit |
| NRC | Nuclear Regulatory Commission |
| NORM | Naturally Occurring Radioactive Material |
| pCi/g | picocuries per gram |
| QC | quality control |
| ^{226}Ra | radium-226 |
| RASO | Radiological Affairs Support Office |
| ROC | radionuclide of concern |
| RSY | Radiological Screening Yard |

ABBREVIATIONS AND ACRONYMS

(Continued)

| | |
|-------------------|------------------------------|
| RTK | real-time kinematic |
| SAP | Sampling and Analysis Plan |
| SOP | standard operating procedure |
| ^{90}Sr | strontium-90 |
| SUPR | Survey Unit Project Report |
| ^{232}Th | thorium-232 |
| VSP | Visual Sample Plan |
| VTA | vehicle towed array |
| WRS | Wilcoxon Rank-Sum |

1.0 INTRODUCTION

1.1 PURPOSE

This Survey Unit Project Reports (SUPRs) Abstract summarizes the scope, approach, and radiological surveys used during removal of the sanitary sewers and storm drains containing naturally occurring radioactive material (NORM) fill material located within Parcel C at Hunters Point Naval Shipyard (HPNS) conducted after March 1, 2013. This Abstract will be applicable to the following SUPRs: 313, 316, 325, 326, 327, 333, 334, 335 and 338, as well as any other SUPRs associated with trench or below surface excavations in Parcel C containing similar physical and radiological characteristics as the NORM fill described in this document (Figure 1-1). The trench areas associated with these SUPRs contained significant quantities of sandy brown material containing NORM Ra-226 and Th-232 activity concentrations well above the typical activity concentrations in the soil from the reference area used in the majority of the SUPRs, either around utility lines or as material beneath roadways.

This Abstract was prepared under Contract No. N62473-10-D-0809, Contract Task Order No. 0012.

1.2 BACKGROUND

Based on the site's operational history described in the final Historical Radiological Assessment (HRA), Volume II (NAVSEA 2004) and site-specific investigative data, the Department of the Navy (DON) determined that the HPNS sanitary sewer and storm drain systems contain radioactive contamination in soils and debris requiring a response action. This decision is documented in the final Base-wide Radiological Removal Action, Action Memorandum (AM) – Revision 2006 (DON 2006), which was created to implement the recommendations of the HRA.

HPNS is a site where radioactive materials have been used or stored, where known spills, discharges, or other instances involving radioactive materials have occurred, and where radioactive materials might have been disposed of or buried. The sanitary sewer and storm drain systems have a potential for general radioactive material contamination based on the site operating history or known contamination detected during previous radiation surveys.

The DON initiated this removal action for the extraction of piping systems and soil containing radioactive contaminants that may be present in or around the sanitary sewer and storm drain systems. This removal action will serve to eliminate the potential threat posed by future migration and/or off-site release of radioactive material present at the site to the surrounding environment. Currently, such a release could occur as a result of wastewater or stormwater transport, erosion, weathering, seismic events, or biological activity.

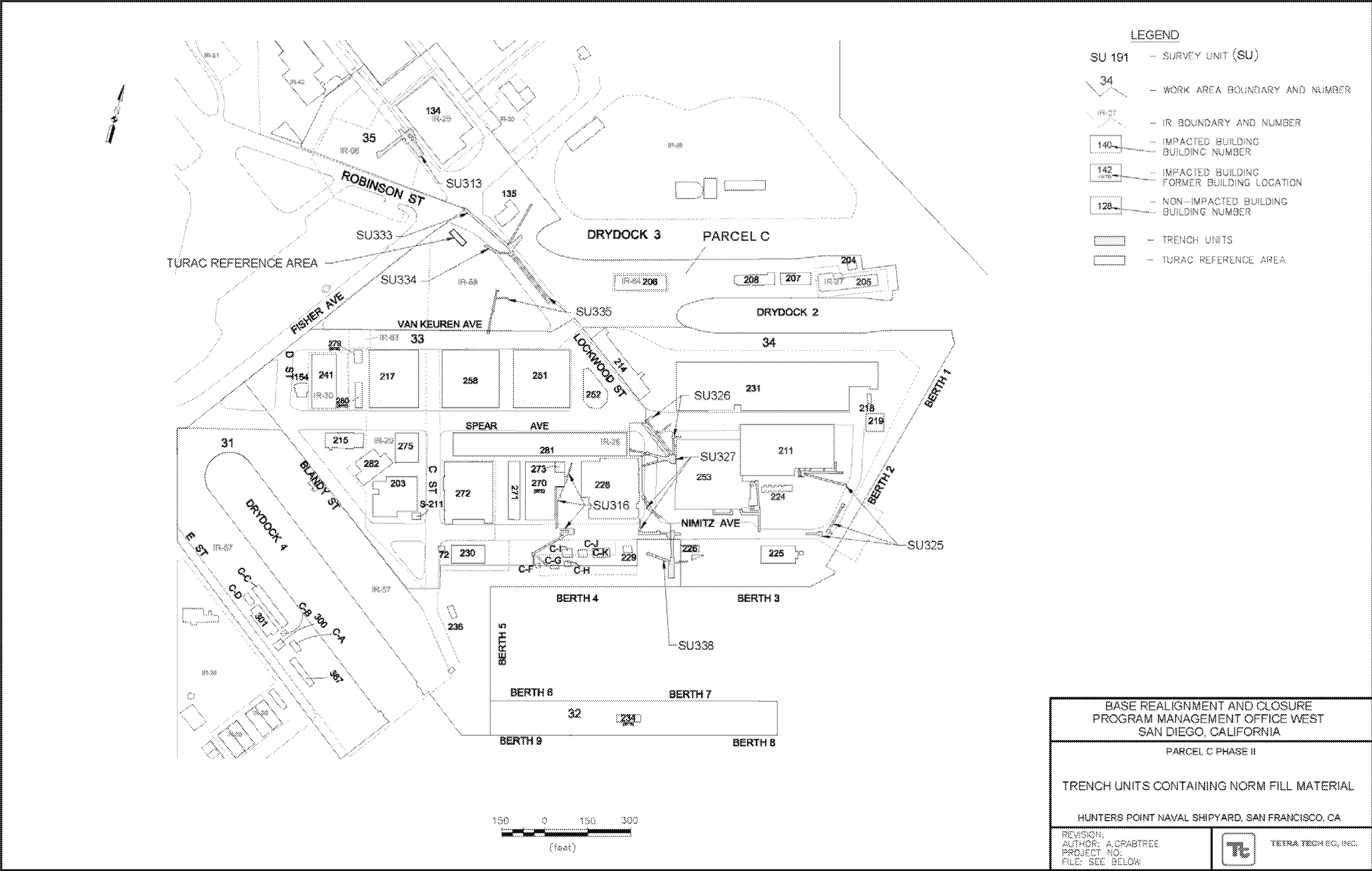
The HRA (NAVSEA 2004) states that the present-day configuration of the sanitary sewer and storm drain systems is the result of an evolutionary process. This system was originally designed and built in the 1940s as a combined system, using the same conveyance piping and 40 separate discharge outfalls into San Francisco Bay.

This combined system grew in sections from the 1940s to its maximum size in 1958, when it underwent the first in a series of separation projects. The Building 819 pump station was constructed for conveyance of much of the sanitary sewage from HPNS to the City of San Francisco treatment works, and separation of the systems took place in the industrial areas and the southwest area of HPNS. Separation of the systems involved installation of dedicated sanitary sewer collection piping or diversion structures within the combined system piping that normally directed all combined flows through the Building 819 pump station. However, during storm events, stormwater flows would overwhelm Building 819, and much of the sewage and stormwater was diverted to various existing outfalls into the bay. Twenty-eight bay outfalls were converted to exclusive use for stormwater outlets, while 12 continued to serve as combined sanitary and stormwater sewer outlets.

A second segregation project, undertaken in 1973, provided some additional separation of the combined systems. The last of the separation projects performed in 1976 involved the installation of additional dedicated sanitary sewer piping. Complete separation of the combined systems was never achieved. Due to the evolutionary nature of the separation process, radiological contamination from the same source could have impacted the piping and other components of both systems.

Geological and radiological analysis of soil types in Parcel C of HPNS indicate that large quantities of NORM fill material were used to construct road base, as well as surround conduit lines. This NORM fill material is characterized by a sandy brown physical characteristic, as well as a radium-226 (^{226}Ra) and thorium-232 (^{232}Th) concentration in excess of 1 pCi/g, with an approximate one to one ratio in activity concentrations. A further description of the NORM fill material is contained in Appendix A, "Geological Analysis of Elevated Concentrations of Naturally Occurring Radioactive Material in Hunters Point Naval Shipyard Parcel C Fill Material". Because this type of material naturally contains elevated concentrations of Ra-226 and Th-232 as compared to materials in the previous reference area used for SUPRs, an appropriate reference area within Parcel C is necessary to prevent the unnecessary disposal of NORM fill material as Low Level Radioactive Waste (LLRW).

FIGURE 1-1
TRENCH UNITS CONTAINING NORM FILL MATERIAL



P:\ACTO-12 CAD Files (Red EMAC)\DWG files\Survey Units\Trench Units Containing NORM Fill Material_11-11-14.dwg

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2.0 RELEASE CRITERIA

2.1 RELEASE LIMITS

The DON is taking steps to ensure that residual radioactivity at an area will not result in individuals being exposed to unacceptable levels of radiation or radioactive materials. Regulatory agencies establish radiation dose standards based on risk considerations and scientific data relating dose to risk. Residual levels of radioactive material that correspond to allowable radiation dose standards are derived by analysis of various pathways and scenarios such as direct exposure, inhalation, and ingestion.

These levels, known as release limits, are presented in terms of soil activity concentration. Release limits usually refer to average levels of radiation or radioactivity above appropriate background levels. Release limits applicable to soil are expressed in units of activity concentration, picocuries per gram (pCi/g). The development of release limits is often an iterative process, where the release limits selected or developed are modified as additional site-specific information is obtained. The development of final cleanup levels was based on the Nuclear Regulatory Commission's (NRC's) screening levels, the U.S. Environmental Protection Agency's (EPA's) preliminary remediation goals, or agreements between the DON and regulatory agencies as documented in the AM.

2.2 AS LOW AS REASONABLY ACHIEVABLE

As low as reasonably achievable (ALARA) is a philosophy of striving for excellence in the practice of health physics and is an important aspect of radiation-safety regulations. The National Council on Radiation Protection and Measurements has stated, "ALARA is simply the continuation of good radiation-protection programs and practices which traditionally have been effective in keeping the average and individual exposures for monitored workers well below the limits" (NCRP 1993). The application of ALARA clearly includes the consideration of economic and social factors, and thus will inherently be different for different sources or facilities.

The ALARA concept is founded in the professional judgment of radiation-safety managers and personnel and is not, therefore, able to be used as a measure as to whether or not a particular radiation-safety program is adequate in comparison with other programs. Additionally, the ALARA concept does not provide a numerical limit below which the ALARA concept is achieved.

2.3 ENVIRONMENTAL ALARA PROCESS

This section describes the steps taken to implement the environmental ALARA policy:

1. Identification of Potential Radiological Impacts
2. Review of Radiological Impacts

3. Performance of Qualitative ALARA Analyses
4. Performance of Quantitative ALARA Analyses

2.3.1 Identification of Potential Radiological Impacts

Each new radiological operation is subjected to ALARA reviews before work begins to ensure that radiation exposures to workers, the public, and the environment meet ALARA principles. ALARA reviews are conducted for all operations, practices, and procedures that have potential for individual or collective doses to workers. Reviews culminate in changes or additions to work planning documents, standard operating procedures (SOPs), and radiological work permits.

These documents are used to identify activities that have potential for radiological environmental impacts and could require environmental ALARA analysis. If a radiological impact is identified that could impact the environment significantly, the Radiation Safety Officer communicates the impact to the work staff and the Radiological Affairs Support Office (RASO).

2.3.2 Review of Radiological Impacts

Radiological impacts to the environment, workers, and the public from field operations are assessed for compliance with ALARA principles. Results from radiological survey activities, and air, soil, sediment, and water samples are used to assess the radiological impacts of HPNS activities.

Determination of environmental radiological impacts from radiological activities is performed using nine methods: 1) air monitoring stations located around the excavation site perimeter to track radiological impacts; 2) field monitoring and sampling to identify areas requiring additional remediation; 3) remediation of contaminated areas at or above the release criteria; 4) control of radiologically impacted areas and work sites; 5) frisking of personnel and examining equipment leaving a radiologically controlled area; 6) use of release criteria that equate to dose and risk; 7) review of historical radiological operations to allow complete investigation of all areas of radiological concern; 8) complete characterization of radiologically impacted sites to ensure complete removal of radioactive material above the release criteria; and 9) dosimetry worn by personnel to measure time-averaged doses from gamma radiation.

2.3.3 Performance of Qualitative ALARA Analyses

Laboratory analyses are performed for radionuclides of concern as well as for a number of naturally occurring radionuclides to ensure that any possible radioactive contamination is identified. After each excavation is completed, the qualitative radiological impacts from operations are evaluated by performing a dose and risk assessment. The results of analysis and assessments are provided to the RASO and regulatory agencies for review.

2.3.4 Performance of Quantitative ALARA Analyses

Based on qualitative ALARA analyses, excavation projects that could cause a potential dose to the public are subjected to quantitative ALARA analyses using the steps described below.

Quantitative ALARA analyses include societal, technological, economic, and public policy considerations. In addition, these ALARA analyses consider NRC guidance for performing the following environmental ALARA assessments:

- Identification of possible radiation protection systems, such as alternative operating methods or controls, that are reasonably achievable. The options should range from the most rudimentary (base case) to the most technologically sophisticated systems.
- Quantification of exposures and doses to workers and the public in the vicinity of the work through air monitoring and dosimetry.
- Quantification of the economic factors, including the costs of purchasing, installing, operating, and maintaining the radiological equipment, and the potential health effects associated with the exposure of people and any other direct or indirect cost resulting from exposures to radiation during investigations and/or remediations.
- Identification and estimation of other health and non-health detriments and benefits, such as equipment loss and accidents.
- Evaluation of process alternatives using a quantitative cost-benefit analysis, when possible. When evaluations included assumptions, judgments, and limitations that could be quantified, and potential doses were well below the dose limit, qualitative analyses were used with full documentation.
- Implementation of the ALARA principles and monitoring of the results.

The following specific factors are used in performing a quantitative ALARA analysis:

- Dose to workers, the public, and the environment before and during work processes
- Residual dose to the local population
- Applicable alternative processes (treatments, operating methods, or controls) for site investigations or remediations
- Costs for each alternative evaluated
- Societal and environmental (positive and negative) impacts associated with alternatives

Based on recent estimates of dose to the public from HPNS operations, only qualitative ALARA analyses were required. Much of the data and analysis used for environmental ALARA evaluations is developed as part of the routine work processes.

To ensure that ALARA levels are met, removal actions conducted in accordance with the AM are designed to 1) substantially reduce ionizing radiation below cleanup goals and 2) eliminate identified pathways of exposure to ionizing radiation.

2.4 RADIONUCLIDES OF CONCERN

As listed in Table 3-1 of the Basewide Storm Drain and Sanitary Sewer Removal Plan (Attachment 1 to the Basewide Radiological Management Plan) (TtEC 2012a), the primary radionuclides of concern (ROCs) for most survey units were cesium-137 (^{137}Cs), radium-226 (^{226}Ra), and strontium-90 (^{90}Sr). Table 2-1 lists those ROCs. The principal types of radiation (alpha, beta, and gamma) and associated half-lives are also identified for measurement purposes.

TABLE 2-1
RADIONUCLIDES OF CONCERN

| Radionuclide | Half-life | Radiations |
|--------------|-------------|---------------------------------------|
| Cesium-137 | 30.17 years | Beta/gamma (β^- , γ) |
| Radium-226 | 1,600 years | Alpha (α)/gamma (γ) |
| Strontium-90 | 28.6 years | Beta (β^-) |

Exceptions to the ROCs will be noted individually in the specific SUPR, as necessary. One hundred percent of the final systematic samples collected were analyzed by gamma spectroscopy at a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) and California Department of Public Health accredited laboratory, Curtis and Tompkins, for definitive data. Ten percent of the final systematic samples were also analyzed for ^{90}Sr at the DoD ELAP accredited laboratory, TestAmerica St. Louis.

The presence of ^{90}Sr would be attributed primarily to fission products associated with OPERATIONS CROSSROADS and decontamination of ships that participated in atomic weapons testing. Since ^{137}Cs would have also been present, any sample containing activity greater than the release criteria for ^{137}Cs was also analyzed for ^{90}Sr .

2.5 RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN

Radionuclide-specific release criteria were obtained for each ROC using the criteria established by the NRC and EPA, as discussed in Section 2.1. The release criteria are shown in Table 2-2. Survey units for the sanitary sewer and storm drain removal project are considered acceptable when the radionuclide concentrations meet the soil release criteria defined in Table 2-2.

TABLE 2-2
RELEASE CRITERIA

| Radionuclide | Soil | | | |
|--------------|---------------------------|--|------------------------|--|
| | Outdoor Worker (pCi/g) | Residual Dose (mrem/y) ^a | Residential (pCi/g) | Residual Dose (mrem/y) ^a |
| Cesium-137 | 0.113 | 0.0735 | 0.113 | 0.2561 |
| Radium-226 | 1.0 ^b | 2.227 | 1.0 ^b | 18.1 |
| Strontium-90 | 10.8 | 0.0637 | 0.331 | 1.648 |

Notes:

^a The resulting dose is based on modeling lead-210 in equilibrium using RESRAD Version 6.5 with radon pathways turned off.

^b Limit is 1 pCi/g above background, per agreement with EPA.

Abbreviations and Acronyms:

EPA – U.S. Environmental Protection Agency

mrem/y – millirems per year

pCi/g – picocuries per gram

2.6 INVESTIGATION LEVEL FOR GAMMA SCAN SURVEYS

Investigation levels are specific levels of radioactivity used to indicate when additional investigation may be necessary. Investigation levels also serve as a quality control (QC) check. For example, in addition to indicating potential contamination, a measurement that exceeds the investigation level may have indicated a failing instrument.

Gamma scan surveys were conducted of all accessible surfaces above the water level of trenches formed after removal of associated piping. A range of these gamma scan measurements is included in Attachment 1 of each individual Survey Unit Project Report (SUPR). Additionally, a gamma static measurement was collected at the points at which each individual accessible systematic sample is collected. Any systematic soil sample locations that were inaccessible (e.g., beneath the water level within the respective trench) were surveyed after the sample had been collected and placed in a plastic Ziploc[®] bag. The results of the gamma static measurements are also included in Attachment 1 of each individual SUPR, with a corresponding note for measurements collected after soil sample removal from beneath the water level in the trench.

When determining an investigation level using a statistical based parameter (for example, standard deviation), the following may be considered: survey objectives, underlying radionuclide distributions (normal, log-normal, nonparametric), data population descriptors (standard deviation, mean, median), and prior survey and historical information.

When an investigation level was exceeded, the measurement would have been confirmed to ensure that the initial measurement actually exceeds a particular investigation level. This involved taking further measurements to confirm the initial result and, as appropriate, to quantify the area of elevated residual radioactivity.

The investigation level for gamma surveys was established as the reference area mean + 3 σ where σ is the standard deviation of the gamma readings in the reference area, or the standard deviation of the gamma readings in the specific survey unit as recommended in Section 5.5.2.6 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG-1575; DoD et al. 2000), with prior approval from RASO. Note that in the case of excavated survey units surveyed on a Radiological Screening Yard (RSY) pad, a maximum of 18 investigative (or biased) soil samples were collected.

3.0 FINAL STATUS SURVEYS

The MARSSIM (NUREG-1575; DoD et al. 2000), the Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey Guide (NUREG-1505; NRC 1998), and the Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions Guide (NUREG-1507; NRC 1997) were used as guidance in designing and conducting the Final Status Surveys (FSSs).

3.1 OBJECTIVE OF THE FINAL STATUS SURVEYS

The objective of the FSS was to demonstrate that identified residual radioactivity levels inside the excavated trench and subsequent overburden soils to be used as backfill met the release criteria.

3.2 SURVEY UNITS

Sanitary sewer and storm drain systems were divided into manageable work areas, as designated in the specific design and work plans that are submitted for regulatory review. Smaller survey units were identified within each work area. There were two types of survey units: trench and excavated soil. Trench survey units are survey units constructed by the surface area remaining as sanitary sewer and storm drain lines, as well as surrounding soil, are removed. Excavated soil survey units are created from the soil excavated during sanitary sewer and storm drain removal, so that the soil can be surveyed to determine its acceptability for use as fill material. Although the size of each survey unit may vary, each received the same scan survey and systematic sampling frequency.

3.2.1 Trench Survey Units

Scan surveys and systematic sampling were performed for each identified survey unit. Trench survey units varied in size but did not exceed 1,000 square meters in surface area. Systematically located postexcavation samples were collected after establishing a grid using Visual Sample Plan (VSP). Additional surveys may have been performed if the investigation levels were exceeded.

Accessible surface areas (e.g., areas above the ground water level) of each trench unit were scanned using Ludlum Model 44-10 2-inch by 2-inch sodium iodide scintillation detectors coupled to Ludlum Model 2350-1 data loggers. The scan surveys were performed at a rate of approximately 0.5 meter per second with the detector held approximately 10 centimeters (4 inches) above the trench sidewalls and floor as appropriate. The detector was moved back and forth across the travel path while scanning, producing a serpentine scan pattern. Areas of elevated activity identified during the scan survey were investigated further. Trench unit scan survey data are provided as an attachment to each individual SUPR.

Each trench unit was mapped using computer-aided design technologies. First, the trench centerline was plotted, and then the extent of the trench excavation was drawn, with walls splayed

out flat, into a two-dimensional plane. The design was then extracted into VSP to determine the locations of systematic sample points.

A minimum of 18 systematic sample locations, based on a random start point and the triangular grid pattern, were generated using VSP and are provided in each SUPR. Sample collection points were placed in the field using approved land surveying technologies and identified with the global positioning system (GPS).

3.2.2 Excavated Soil Survey Units

During the course of excavation from Parcels C, E, and E-2 sanitary sewer and storm drain lines, the soils from these excavations were removed to dewatering/screening pads located in the Radiological Screening Yards (RSYs). The soils were then spread out in lifts not to exceed 6 inches in thickness and 1,000 square meters in total surface area. Each of these areas was then assigned an incremental number and identified as an excavated soil unit (ESU).

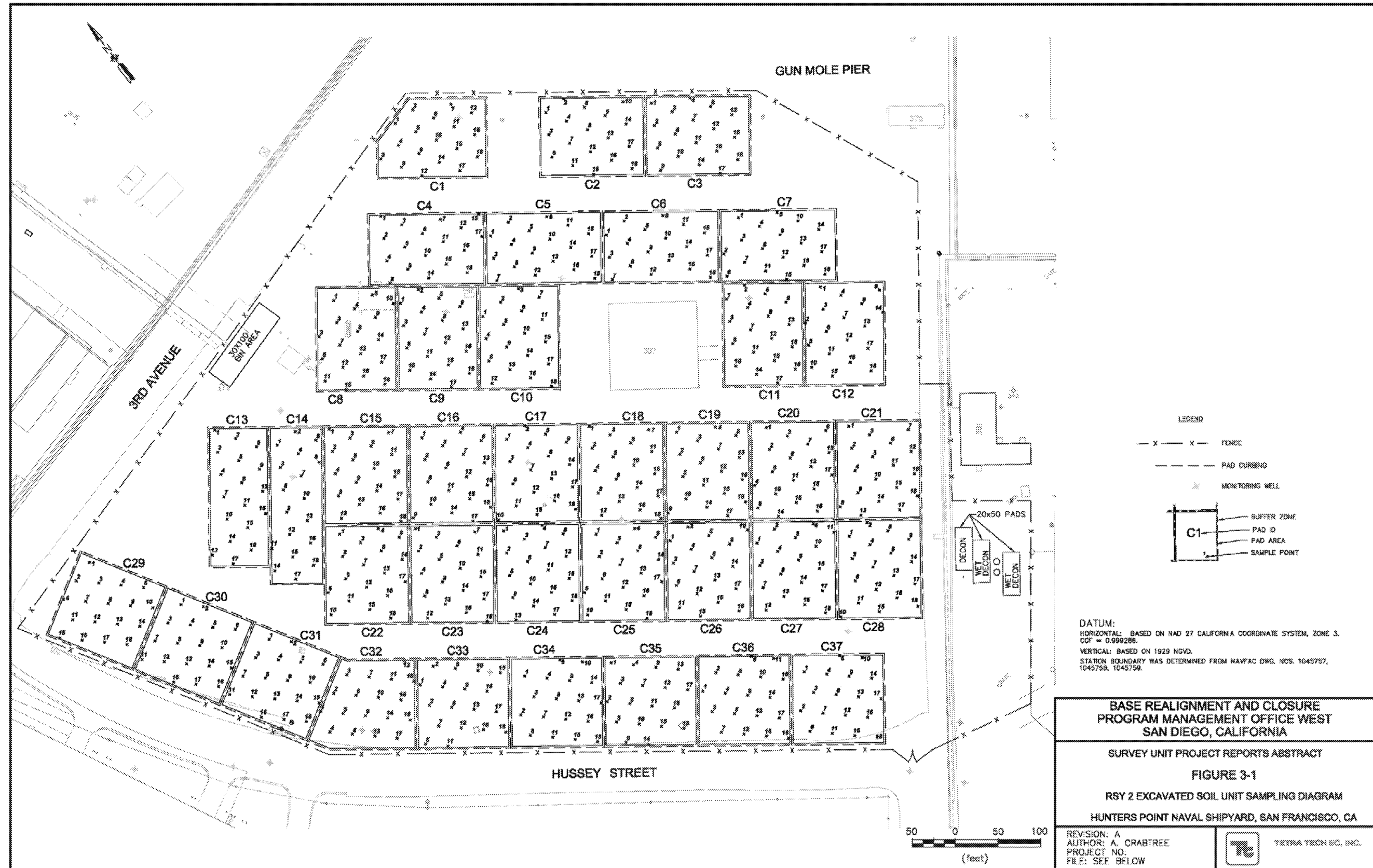
The gamma scan data for each ESU are presented as an attachment to each SUPR, as applicable.

The entire area of each ESU was plotted in VSP, and 18 systematic sampling locations were determined using a random start point on a triangular grid pattern. A maximum of 18 biased samples were collected for each ESU based on the investigation levels as described in Section 2.6. Typical systematic sampling locations used for each ESU are shown on Figures 3-1, 3-2, and 3-3. The final sampling locations of ESUs are provided in each SUPR, as applicable.

3.2.3 Soil Scanning at the Radiological Screening Yard

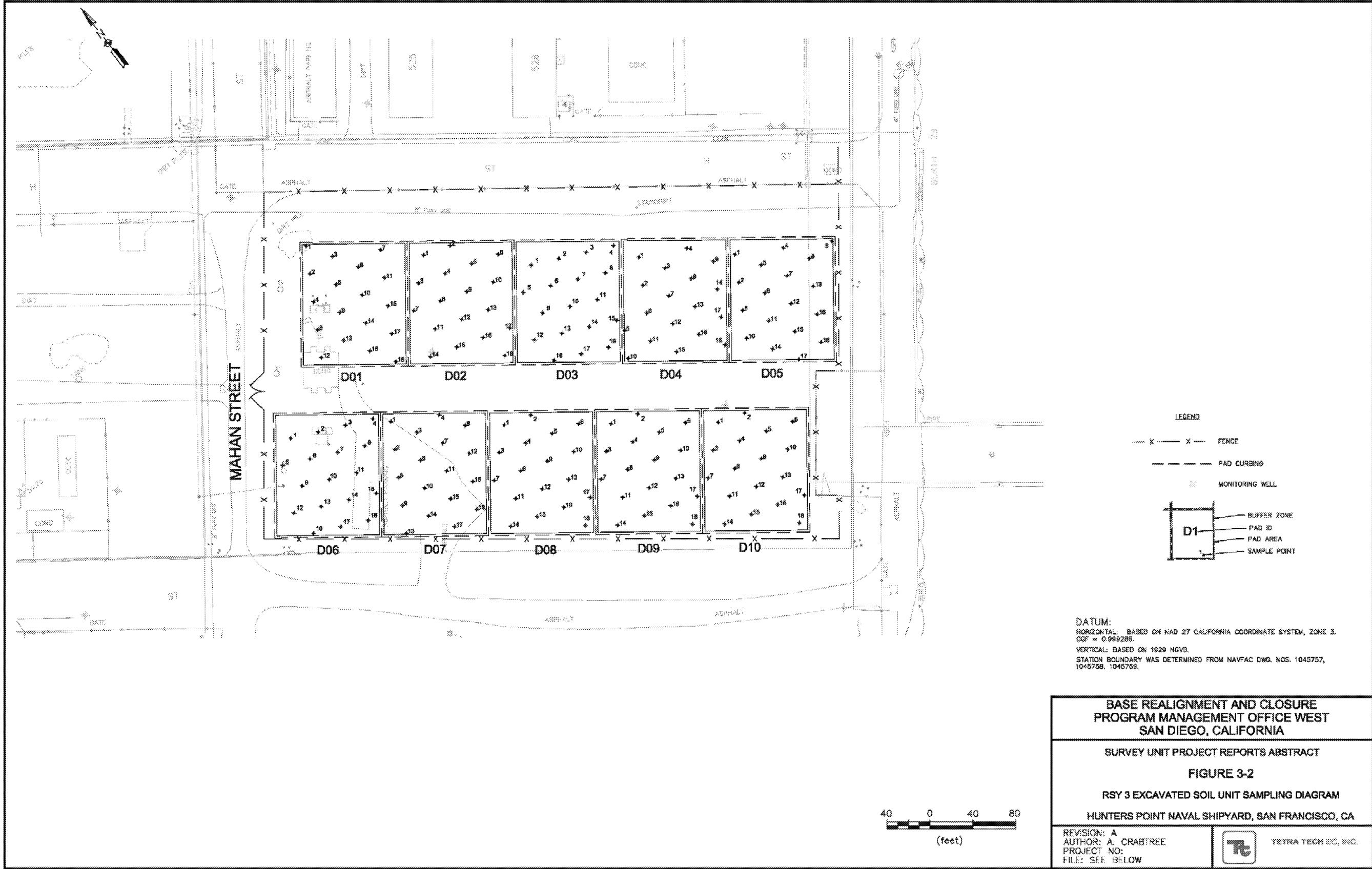
Each ESU was scanned using a towed array system. For the sanitary sewer and storm drain systems surveyed under this SUPRs Abstract, a vehicle towed array (VTA) was used.

FIGURE 3-1
RSY-2 EXCAVATED SOIL UNIT SAMPLING DIAGRAM



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FIGURE 3-2
RSY-3 EXCAVATED SOIL UNIT SAMPLING DIAGRAM

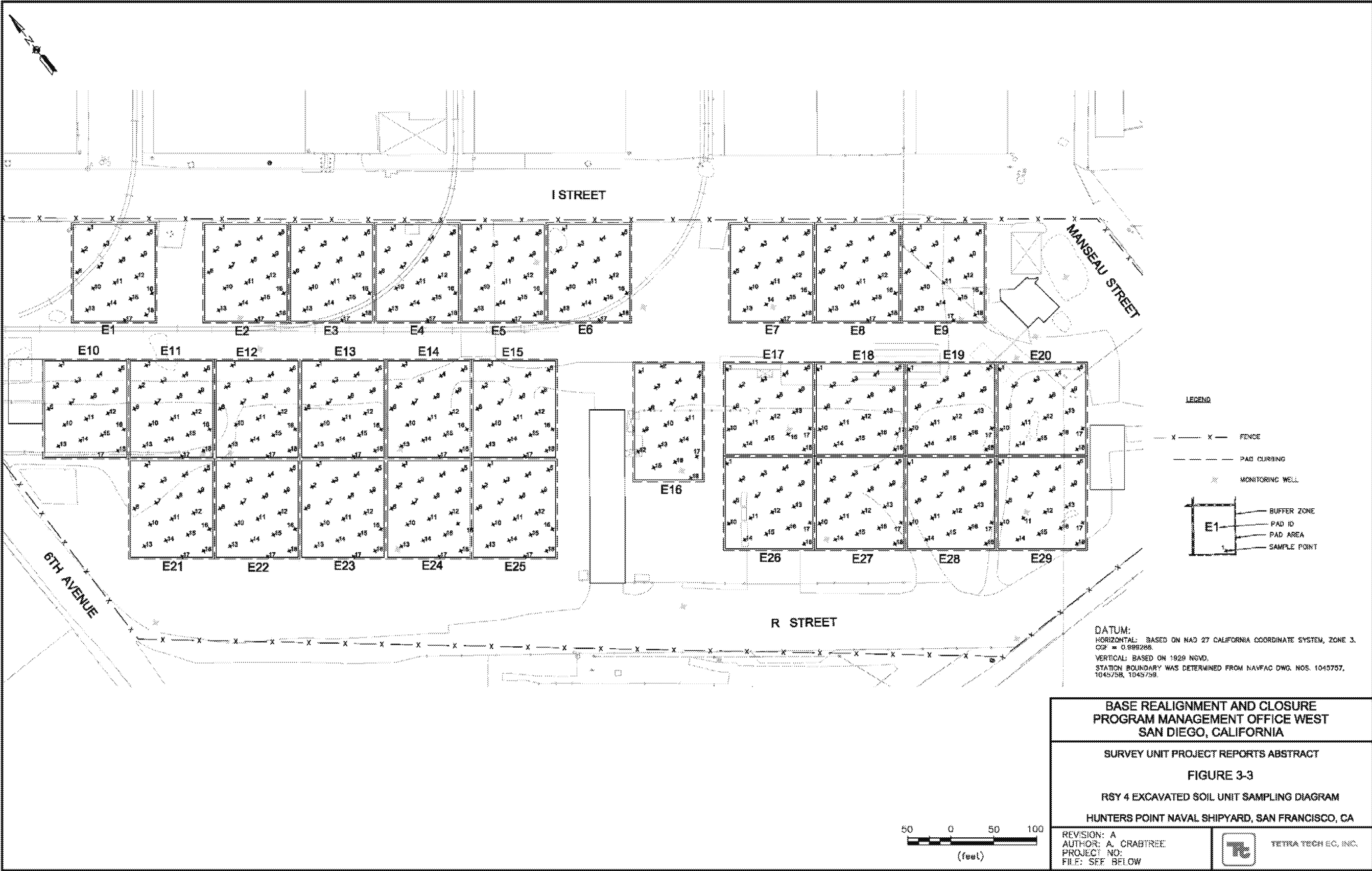


P:\CAD PROJECT FILES\CTO 006\TO 70 PARCEL D\PARCEL D WORKING FILES\RSY AREA\HPS-RSY 3-003_04-18-11.DWG

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FIGURE 3-3
RSY-4 EXCAVATED SOIL UNIT SAMPLING DIAGRAM



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The VTA system was used in support of radiological clearance of remediated soil over areas with relatively flat terrain and/or radiological screening pads. The system is constructed with two 12- × 39- × 1.5-inch (30.5- × 99- × 3.8-centimeter) DA372 organic plastic scintillators manufactured by TSA, coupled to a TSA Model SC-770 data controller, with positioning provided by three dual-frequency, high-resolution Leica GPSs with real-time kinematic (RTK) positioning capabilities that provide fixed solution accuracy (1 to 5 centimeters). One GPS is for the detector positioning, one GPS is for the swath guidance system, and one GPS is for the RTK base station. The system integrates both GPS and counts from the detector. The SC-770 is designed to provide a mobile platform capable of measuring both gamma radiation and GPS very accurately.

The GPS system was selected based on the ability to reliably measure position within 5 centimeters of the center of the detector. This GPS system has been used extensively for unexploded ordnance work for Tetra Tech EC, Inc. Scan speeds of the system are limited to an average of 0.5 meter per second or 1.8 kilometers per hour with a detector height of 4 inches, which is consistent with the detector height presented in NUREG-1507 and is slow enough to provide adequate data acquisition over each surface area.

3.2.4 Import Fill

In February 2007, a local source of import fill material was found in the Burlingame, California, area from the expansion of the Mills Hospital facility. This soil was screened both chemically and radiologically before being delivered for use as residential fill material at HPNS. This import fill material met the standards specified in Table A.7-1 of the Sampling and Analysis Plan (SAP) (TtEC 2008) and Worksheet #15.1 of the SAP (TtEC 2011). Approximately 100,000 cubic yards of the material was stockpiled at HPNS.

In 2011, import fill material was purchased from Jericho. This soil was screened both chemically and radiologically before being delivered for use as residential fill material at HPNS. This import fill material also met the standards specified in Worksheet #15.1 of the SAP (TtEC 2011), and approximately 40,000 cubic yards of the material was stockpiled at HPNS.

Eighteen random soil samples were collected from the Mills Hospital import fill stockpile, and 20 random soil samples were collected from the Jericho import fill stockpile. The samples were analyzed by gamma spectroscopy. The results of the random soil samples are used when performing dose modeling when import fill material was used to backfill a trench.

The import fill material gamma spectroscopy and ⁹⁰Sr results are provided in Attachment 1. Table 3-1 provides a summary of the results of the import fill material from the Mills Hospital facility. Table 3-2 provides a summary of the results of the import fill material from Jericho.

3.3 REFERENCE AREA

Reference area samples for the sanitary sewer and storm drain removal project were obtained in December 2013 in an unimpacted area to the southeast of Lockwood Avenue adjacent to Parcel C. Eighteen samples were collected systematically from this area for reference area purposes. All 18 samples were analyzed at the DoD ELAP accredited laboratory by gamma spectroscopy. The reference area samples provided a basis for net activity concentration.

Background activity for ^{226}Ra , based on the mean of the greater of the reported activity or minimum detectable activity (MDA), measured by a minimum of a 21-day in-growth of the 609.31 keV gamma energy peak for bismuth-214 (^{214}Bi), was determined to be 1.057 pCi/g. This places the release criterion at 2.057 pCi/g of ^{226}Ra for final definitive data, as well as radiological remediation decisions based on application of a shortened in-growth period in conjunction with a correlated ^{214}Bi in-growth factor. Note that this value is used in each SUPR for background subtraction of ^{226}Ra for dose and risk modeling.

The reference area gamma spectroscopy results from the DoD ELAP accredited are provided in Attachment 2. A summary of the results is provided in Table 3-3.

3.4 ADDITIONAL REFERENCE AREA RADIOANALYTICAL DATA

Seven of the reference area soil samples were selected at random and analyzed for actinium-228 (Ac-228), lead-212 (Pb-212), thorium-234 (Th-234), lead-214 (Pb-214) and bismuth-214 (Bi-214) using gamma spectroscopy analysis at the onsite DoD ELAP accredited laboratory for an extended count time of eight hours to minimize activity concentration uncertainties. These same samples were also analyzed at the TestAmerica St. Louis DoD ELAP accredited laboratory using alpha spectroscopy for thorium-232 (Th-232), thorium-228 (Th-228), uranium-238 (U-238) uranium 233/234 (U-233/234) and thorium-230 (Th-230). This data was used to establish that the Th-232 natural decay series (Th-232 to Ac-228 to Th-228 to Pb-212 to Bi-212) and the U-238 natural decay series (U-238 to Th-234 to U-234 to Th-230 to Pb-214 and Bi-214) were in secular equilibrium (i.e., the activity concentrations for each radionuclide in the decay chain are essentially equivalent taking into account uncertainties of the analytical methods), and, therefore, the comparatively elevated activity concentrations of Ra-226 and Th-232 can logically be deduced to be from naturally occurring radioactive materials in the material, as opposed to radiological contamination as the result of HPNS operations within the past 100 years. The approximate 1:1 ratio of Th-232 to Ra-226 was also demonstrated. The alpha spectroscopy and gamma spectroscopy extended count time results are contained in Attachment 2. Furthermore, the radiological concentration of naturally occurring radioactive materials from the reference area samples are similar to those from a sample from the Colma Formation exposed in the cliffs at Fort Funston (Sample 04-FUNST-003), indicating that this material may have been imported for use as fill. Additional discussions concerning the geological similarities between the Colma Formation

and the NORM fill material are contained in Appendix A. A summary of the results organized by the Th-232 and U-238 decay chains are provided in Tables 3-4 and 3-5, respectively.

As a further measure, the soil samples were also analyzed by alpha spectroscopy at the TestAmerica St. Louis DoD ELAP accredited laboratory for plutonium-239 (Pu-239) to ensure potential contamination due to nuclear weapons testing, as Cs-137 concentrations as determined by gamma spectroscopy did not indicate fission fragments above background concentration. All results indicated activities less than the method detection limit. The alpha spectroscopy results are contained in Attachment 2. A summary of the results is provided in Table 3-6.

TABLE 3-1

Import Fill Material - Mills Peninsula (Definitive)

| Sample No. | Date | Time | ¹³⁷ Cs | Flag | MDA | ≥MDA | ⁹⁰ Sr | Flag | MDC | ≥MDC | ²²⁶ Ra | Flag | MDA | ≥MDA |
|------------|-----------|----------|-------------------|------|-------|-------|------------------|------|-------|-------|-------------------|------|-------|-------|
| 1 | 2/19/2007 | 7:30:00 | 0.027 | | 0.025 | 0.027 | | | | | 0.545 | | 0.031 | 0.545 |
| 2 | 2/19/2007 | 7:40:00 | 0.007 | U | 0.025 | 0.025 | | | | | 0.491 | | 0.043 | 0.491 |
| 3 | 2/19/2007 | 7:50:00 | 0.015 | U | 0.024 | 0.024 | | | | | 0.591 | | 0.035 | 0.591 |
| 4 | 2/19/2007 | 8:00:00 | 0.007 | U | 0.020 | 0.020 | | | | | 0.530 | | 0.033 | 0.530 |
| 5 | 2/19/2007 | 8:10:00 | 0.000 | U | 0.039 | 0.039 | | | | | 0.395 | | 0.042 | 0.395 |
| 6 | 2/19/2007 | 8:20:00 | 0.027 | | 0.021 | 0.027 | -0.003 | | 0.068 | 0.068 | 0.535 | | 0.040 | 0.535 |
| 7 | 2/19/2007 | 8:30:00 | -0.007 | U | 0.025 | 0.025 | | | | | 0.490 | | 0.036 | 0.490 |
| 8 | 2/19/2007 | 8:40:00 | 0.011 | U | 0.024 | 0.024 | | | | | 0.382 | | 0.024 | 0.382 |
| 9 | 2/19/2007 | 8:50:00 | 0.000 | U | 0.033 | 0.033 | | | | | 0.364 | | 0.027 | 0.364 |
| 10 | 2/19/2007 | 9:00:00 | 0.006 | U | 0.016 | 0.016 | | | | | 0.327 | | 0.031 | 0.327 |
| 11 | 2/19/2007 | 9:10:00 | -0.009 | U | 0.028 | 0.028 | | | | | 0.412 | | 0.033 | 0.412 |
| 12 | 2/12/2007 | 9:20:00 | 0.002 | U | 0.021 | 0.021 | | | | | 0.425 | | 0.032 | 0.425 |
| 13 | 2/19/2007 | 9:30:00 | 0.002 | U | 0.023 | 0.023 | | | | | 0.374 | | 0.028 | 0.374 |
| 14 | 2/19/2007 | 9:40:00 | 0.005 | U | 0.020 | 0.020 | | | | | 0.429 | | 0.031 | 0.429 |
| 15 | 2/19/2007 | 9:50:00 | -0.006 | U | 0.023 | 0.023 | | | | | 0.418 | | 0.035 | 0.418 |
| 16 | 2/19/2007 | 10:00:00 | -0.009 | U | 0.029 | 0.029 | 0.016 | | 0.072 | 0.072 | 0.520 | | 0.030 | 0.520 |
| 17 | 2/19/2007 | 10:10:00 | 0.020 | U | 0.022 | 0.022 | | | | | 0.502 | | 0.029 | 0.502 |
| 18 | 2/19/2007 | 10:20:00 | -0.002 | U | 0.026 | 0.026 | | | | | 0.518 | | 0.038 | 0.518 |
| mean | | | | | | 0.025 | | | | 0.070 | | | | 0.458 |
| std dev | | | | | | 0.005 | | | | 0.003 | | | | 0.075 |
| median | | | | | | 0.024 | | | | 0.070 | | | | 0.459 |

Notes:

Information concerning flags associated with the on-site laboratory data can be found in Section 4.3.

Abbreviations and Acronyms:

¹³⁷Cs – cesium-137

MDA – minimum detectable activity

MDC – minimum detectable concentration

pCi/g – picocuries per gram

²²⁶Ra – radium-226

⁹⁰Sr – strontium-90

std dev – standard deviation

TABLE 3-2

Import Fill Material - Jericho (Definitive)

| Sample No. | Date | Time | ¹³⁷ Cs | Flag | MDA | ≥MDA | ⁹⁰ Sr | Flag | MDL | ≥MDL | ²²⁶ Ra | Flag | MDA | ≥MDA |
|------------|-----------|----------|-------------------|------|-------|-------|------------------|------|-------|-------|-------------------|------|-------|-------|
| 1 | 5/13/2011 | 10:00:00 | 0.000 | U | 0.020 | 0.020 | | | | | 0.289 | | 0.027 | 0.289 |
| 2 | 5/13/2011 | 10:05:00 | 0.014 | U | 0.019 | 0.019 | -0.122 | U | 0.148 | 0.148 | 0.276 | | 0.038 | 0.276 |
| 3 | 5/13/2011 | 10:10:00 | 0.005 | U | 0.019 | 0.019 | | | | | 0.313 | | 0.029 | 0.313 |
| 4 | 5/13/2011 | 10:15:00 | 0.006 | U | 0.018 | 0.018 | | | | | 0.278 | | 0.037 | 0.278 |
| 5 | 5/13/2011 | 10:20:00 | 0.013 | U | 0.016 | 0.016 | | | | | 0.383 | | 0.034 | 0.383 |
| 6 | 5/13/2011 | 10:25:00 | 0.014 | U | 0.019 | 0.019 | | | | | 0.335 | | 0.033 | 0.335 |
| 7 | 5/13/2011 | 10:30:00 | 0.003 | U | 0.022 | 0.022 | | | | | 0.344 | | 0.044 | 0.344 |
| 8 | 5/13/2011 | 10:35:00 | -0.007 | U | 0.020 | 0.020 | | | | | 0.363 | | 0.030 | 0.363 |
| 9 | 5/13/2011 | 10:40:00 | 0.003 | U | 0.020 | 0.020 | | | | | 0.413 | | 0.032 | 0.413 |
| 10 | 5/13/2011 | 10:45:00 | -0.003 | U | 0.018 | 0.018 | | | | | 0.372 | | 0.038 | 0.372 |
| 11 | 5/13/2011 | 10:50:00 | 0.001 | U | 0.023 | 0.023 | | | | | 0.387 | | 0.033 | 0.387 |
| 12 | 5/13/2011 | 10:55:00 | 0.018 | U | 0.019 | 0.019 | 0.156 | | 0.152 | 0.156 | 0.376 | | 0.028 | 0.376 |
| 13 | 5/13/2011 | 11:00:00 | 0.008 | U | 0.016 | 0.016 | | | | | 0.408 | | 0.024 | 0.408 |
| 14 | 5/13/2011 | 11:05:00 | 0.010 | U | 0.020 | 0.020 | | | | | 0.253 | | 0.042 | 0.253 |
| 15 | 5/13/2011 | 11:10:00 | 0.001 | U | 0.020 | 0.020 | | | | | 0.366 | | 0.032 | 0.366 |
| 16 | 5/13/2011 | 11:15:00 | 0.002 | U | 0.016 | 0.016 | | | | | 0.330 | | 0.034 | 0.330 |
| 17 | 5/13/2011 | 11:20:00 | 0.008 | U | 0.018 | 0.018 | | | | | 0.410 | | 0.036 | 0.410 |
| 18 | 5/13/2011 | 11:25:00 | 0.005 | U | 0.022 | 0.022 | | | | | 0.346 | | 0.036 | 0.346 |
| 19 | 5/13/2011 | 11:30:00 | 0.004 | U | 0.021 | 0.021 | | | | | 0.346 | | 0.036 | 0.346 |
| 20 | 5/13/2011 | 11:35:00 | 0.011 | U | 0.023 | 0.023 | | | | | 0.342 | | 0.034 | 0.342 |
| mean | | | | | | 0.020 | | | | 0.152 | | | | 0.347 |
| std dev | | | | | | 0.002 | | | | 0.006 | | | | 0.046 |
| median | | | | | | 0.020 | | | | 0.152 | | | | 0.346 |

Notes:

Information concerning flags associated with the on-site laboratory data can be found in Section 4.3.

Abbreviations and Acronyms:

¹³⁷Cs – cesium-137

MDA – minimum detectable activity

MDL – method detection limit

pCi/g – picocuries per gram

²²⁶Ra – radium-226

⁹⁰Sr – strontium-90

std dev – standard deviation

TABLE 3-3

NORM Fill Material Reference Area Soil Measurements (Definitive)

| Sample No. | Date | Time | Results (pCi/g) | | | | | | | | | | | | | | | | | |
|------------|------------|----------|-------------------|-------|----------|-------------------|-------|----------|------------------|-------|----------|-------------------|-------|----------|-------------------|-------|----------|------------------|-------|----------|
| | | | ²⁴¹ Am | MDA | 2σ Total | ¹³⁷ Cs | MDA | 2σ Total | ⁶⁰ Co | MDA | 2σ Total | ²²⁶ Ra | MDA | 2σ Total | ²³² Th | MDA | 2σ Total | ²³⁵ U | MDA | 2σ Total |
| 1 | 12/20/2013 | 10:25:00 | -0.088 | 0.192 | 0.236 | -0.013 | 0.028 | 0.035 | 0.001 | 0.025 | 0.031 | 1.105 | 0.046 | 0.129 | 1.538 | 0.076 | 0.202 | 0.108 | 0.193 | 0.050 |
| 2 | 12/20/2013 | 10:27:00 | 0.008 | 0.172 | 0.209 | -0.017 | 0.029 | 0.037 | 0.014 | 0.017 | 0.023 | 1.175 | 0.056 | 0.147 | 1.922 | 0.039 | 0.236 | 0.234 | 0.149 | 0.197 |
| 3 | 12/20/2013 | 10:29:00 | -0.021 | 0.214 | 0.261 | 0.016 | 0.016 | 0.022 | -0.001 | 0.025 | 0.030 | 1.062 | 0.052 | 0.135 | 1.493 | 0.045 | 0.198 | 0.118 | 0.216 | 0.051 |
| 4 | 12/20/2013 | 10:30:00 | 0.116 | 0.180 | 0.224 | -0.018 | 0.028 | 0.035 | -0.005 | 0.025 | 0.030 | 1.060 | 0.053 | 0.133 | 1.497 | 0.074 | 0.178 | 0.128 | 0.201 | 0.061 |
| 5 | 12/20/2013 | 10:31:00 | -0.008 | 0.216 | 0.262 | -0.002 | 0.023 | 0.028 | -0.001 | 0.025 | 0.031 | 0.983 | 0.050 | 0.128 | 1.378 | 0.085 | 0.204 | 0.128 | 0.202 | 0.055 |
| 6 | 12/20/2013 | 10:32:00 | 0.083 | 0.156 | 0.194 | 0.008 | 0.025 | 0.031 | 0.001 | 0.012 | 0.018 | 0.924 | 0.054 | 0.132 | 1.165 | 0.079 | 0.150 | 0.076 | 0.187 | 0.056 |
| 7 | 12/20/2013 | 10:33:00 | 0.000 | 0.177 | 0.214 | -0.004 | 0.022 | 0.027 | 0.001 | 0.024 | 0.012 | 0.945 | 0.046 | 0.125 | 1.352 | 0.073 | 0.201 | 0.154 | 0.162 | 0.221 |
| 8 | 12/20/2013 | 10:34:00 | -0.042 | 0.196 | 0.240 | -0.010 | 0.025 | 0.031 | 0.011 | 0.018 | 0.020 | 1.074 | 0.058 | 0.142 | 1.310 | 0.073 | 0.172 | 0.181 | 0.171 | 0.216 |
| 9 | 12/20/2013 | 10:35:00 | 0.005 | 0.178 | 0.217 | -0.008 | 0.026 | 0.033 | 0.007 | 0.022 | 0.028 | 0.867 | 0.053 | 0.127 | 1.408 | 0.027 | 0.200 | 0.037 | 0.192 | 0.042 |
| 10 | 12/20/2013 | 10:36:00 | -0.109 | 0.227 | 0.280 | 0.006 | 0.026 | 0.032 | -0.005 | 0.024 | 0.030 | 1.091 | 0.050 | 0.129 | 1.744 | 0.068 | 0.193 | 0.105 | 0.210 | 0.049 |
| 11 | 12/20/2013 | 10:37:00 | -0.059 | 0.175 | 0.215 | 0.012 | 0.024 | 0.030 | -0.005 | 0.024 | 0.030 | 1.112 | 0.044 | 0.124 | 1.804 | 0.075 | 0.165 | 0.135 | 0.193 | 0.048 |
| 12 | 12/20/2013 | 10:38:00 | 0.035 | 0.159 | 0.195 | -0.006 | 0.026 | 0.032 | -0.007 | 0.027 | 0.034 | 0.967 | 0.057 | 0.144 | 1.349 | 0.078 | 0.208 | 0.124 | 0.192 | 0.049 |
| 13 | 12/20/2013 | 10:39:00 | 0.100 | 0.202 | 0.251 | -0.006 | 0.026 | 0.032 | -0.002 | 0.027 | 0.003 | 1.053 | 0.054 | 0.133 | 1.456 | 0.098 | 0.185 | 0.100 | 0.171 | 0.046 |
| 14 | 12/20/2013 | 10:40:00 | 0.006 | 0.223 | 0.271 | 0.000 | 0.024 | 0.029 | 0.006 | 0.019 | 0.024 | 0.986 | 0.045 | 0.121 | 1.565 | 0.069 | 0.163 | 0.076 | 0.199 | 0.063 |
| 15 | 12/20/2013 | 10:41:00 | 0.000 | 0.206 | 0.250 | 0.010 | 0.025 | 0.032 | 0.004 | 0.027 | 0.022 | 0.966 | 0.048 | 0.130 | 1.445 | 0.061 | 0.203 | 0.114 | 0.226 | 0.048 |
| 16 | 12/20/2013 | 10:42:00 | -0.049 | 0.200 | 0.245 | 0.007 | 0.026 | 0.032 | -0.003 | 0.024 | 0.030 | 1.103 | 0.042 | 0.133 | 1.286 | 0.099 | 0.188 | 0.104 | 0.207 | 0.046 |
| 17 | 12/20/2013 | 10:43:00 | 0.041 | 0.172 | 0.211 | -0.012 | 0.030 | 0.038 | 0.004 | 0.026 | 0.010 | 1.381 | 0.050 | 0.151 | 1.619 | 0.098 | 0.185 | 0.126 | 0.212 | 0.048 |
| 18 | 12/20/2013 | 10:44:00 | -0.002 | 0.207 | 0.252 | 0.000 | 0.025 | 0.030 | -0.010 | 0.024 | 0.031 | 1.177 | 0.053 | 0.140 | 1.469 | 0.080 | 0.181 | 0.123 | 0.197 | 0.049 |
| mean | | | 0.001 | | | -0.002 | | | 0.001 | | | 1.057 | | | 1.489 | | | 0.121 | | |
| std dev | | | 0.060 | | | 0.010 | | | 0.006 | | | 0.118 | | | 0.190 | | | 0.042 | | |
| median | | | 0.000 | | | -0.003 | | | 0.000 | | | 1.061 | | | 1.463 | | | 0.121 | | |

Notes:

Information concerning flags associated with the on-site laboratory data can be found in Section 4.3.

Abbreviations and Acronyms:

¹³⁷Cs – cesium-137

MDA – minimum detectable activity

MDC – minimum detectable concentration

pCi/g – picocuries per gram

²²⁶Ra – radium-226

std dev – standard deviation

²³²Th – thorium-232

TABLE 3-4

NORM Fill Material – Thorium-232 Decay Series Results

| Sample ID | Th-232 Natural Decay Series (pCi/g) | | | | | | | | | | | | | | |
|---------------|-------------------------------------|-------------|---------|---------------------|-------------|---------|---------------------|-------------|--------|---------------------|-------------|---------|---------------------|-------------|---------|
| | Th-232 (alpha spec) | | | Ac-228 (gamma spec) | | | Th-228 (alpha spec) | | | Pb-212 (gamma spec) | | | Bi-212 (gamma spec) | | |
| | Activity | Uncertainty | MDL | Activity | Uncertainty | MDA | Activity | Uncertainty | MDL | Activity | Uncertainty | MDA | Activity | Uncertainty | MDA |
| 04A-FUNST-003 | 1.30 | 0.167 | 0.00722 | 1.616 | 0.05687 | 0.02464 | 1.25 | 0.166 | 0.0251 | 1.534 | 0.03878 | 0.01786 | 2.011 | 0.2322 | 0.1129 |
| 3 | 1.13 | 0.137 | 0.00497 | 1.490 | 0.06186 | 0.03019 | 1.12 | 0.139 | 0.0229 | 1.559 | 0.03622 | 0.01432 | 1.711 | 0.1940 | 0.09844 |
| 7 | 1.17 | 0.139 | 0.00477 | 1.204 | 0.06046 | 0.02768 | 1.23 | 0.146 | 0.0166 | 1.068 | 0.03456 | 0.01661 | 1.427 | 0.2145 | 0.1065 |
| 8 | 1.11 | 0.159 | 0.00866 | 1.228 | 0.05203 | 0.02821 | 0.96 | 0.151 | 0.0358 | 1.131 | 0.03573 | 0.01701 | 1.373 | 0.2063 | 0.106 |
| 9 | 1.10 | 0.134 | 0.00491 | 1.153 | 0.05416 | 0.03143 | 1.16 | 0.14 | 0.0163 | 1.173 | 0.03193 | 0.01397 | 1.271 | 0.1669 | 0.08902 |
| 12 | 1.21 | 0.143 | 0.00490 | 1.382 | 0.05992 | 0.02974 | 1.18 | 0.142 | 0.0184 | 1.272 | 0.03751 | 0.01737 | 1.540 | 0.2148 | 0.1087 |
| 15 | 1.17 | 0.140 | 0.00494 | 1.270 | 0.05452 | 0.02692 | 1.14 | 0.139 | 0.0171 | 1.296 | 0.03294 | 0.01326 | 1.466 | 0.2392 | 0.119 |
| 16 | 1.19 | 0.140 | 0.00355 | 1.365 | 0.06002 | 0.03013 | 1.24 | 0.146 | 0.0204 | 1.375 | 0.03458 | 0.01397 | 1.638 | 0.2258 | 0.1135 |

Abbreviations and Acronyms:

Ac-228– actinium-228

Bi-212 – bismuth-212

MDA – minimum detectable activity

MDL – method detection limit

Pb-212 – lead-212

pCi/g – picocuries per gram

Th-228 – thorium-228

Th-232 – thorium-232

TABLE 3-5

NORM Fill Material – Uranium-238 Decay Series Results

| Sample ID | U-238 Natural Decay Series (pCi/g) | | | | | | | | | | | | | | |
|---------------|------------------------------------|-------------|---------|---------------------|-------------|--------|------------------------|-------------|---------|---------------------|-------------|---------|---------------------|-------------|---------|
| | U-238 (alpha spec) | | | Th-234 (gamma spec) | | | U-233/234 (alpha spec) | | | Th-230 (alpha spec) | | | Pb-214 (gamma spec) | | |
| | Activity | Uncertainty | MDL | Activity | Uncertainty | MDA | Activity | Uncertainty | MDL | Activity | Uncertainty | MDL | Activity | Uncertainty | MDA |
| 04A-FUNST-003 | 0.929 | 0.103 | 0.0039 | 1.026 | 0.2422 | 0.3644 | 0.946 | 0.104 | 0.00276 | 1.15 | 0.154 | 0.00725 | 1.391 | 0.04204 | 0.02034 |
| 3 | 0.955 | 0.102 | 0.00242 | 0.9371 | 0.2388 | 0.358 | 0.925 | 0.0995 | 0.00343 | 0.827 | 0.11 | 0.00866 | 1.265 | 0.04465 | 0.01847 |
| 7 | 0.705 | 0.0799 | 0.00237 | 0.9903 | 0.232 | 0.4045 | 0.734 | 0.0825 | 0.00238 | 0.948 | 0.119 | 0.00678 | 1.023 | 0.04085 | 0.01728 |
| 8 | 0.687 | 0.0794 | 0.00251 | 0.964 | 0.2656 | 0.4316 | 0.655 | 0.0769 | 0.00562 | 0.914 | 0.141 | 0.0123 | 1.111 | 0.03922 | 0.01714 |
| 9 | 0.731 | 0.0834 | 0.00254 | 0.9823 | 0.2105 | 0.5226 | 0.753 | 0.0855 | 0.00359 | 0.839 | 0.11 | 0.00493 | 1.039 | 0.03899 | 0.01843 |
| 12 | 0.637 | 0.0744 | 0.00344 | 0.8442 | 0.2319 | 0.3574 | 0.632 | 0.0742 | 0.00488 | 1.71 | 0.188 | 0.00697 | 1.171 | 0.04848 | 0.02078 |
| 15 | 0.99 | 0.105 | 0.00423 | 0.9626 | 0.2641 | 0.3923 | 0.866 | 0.0947 | 0.0049 | 0.848 | 0.112 | 0.00992 | 1.047 | 0.04091 | 0.01786 |
| 16 | 0.691 | 0.0788 | 0.00411 | 0.9631 | 0.2346 | 0.4008 | 0.714 | 0.0808 | 0.00336 | 0.875 | 0.112 | 0.0047 | 1.137 | 0.04434 | 0.0192 |

Abbreviations and Acronyms:

Bi-214 – bismuth-214

MDA – minimum detectable activity

MDL – method detection limit

Pb-214 – lead-214

pCi/g – picocuries per gram

Th-230 – thorium-230

Th-234 – thorium-234

U-233/234 – uranium-233/234

U-238 – uranium-238

TABLE 3-6**NORM Fill Material – Plutonium-239 Results**

| | Pu-239 (pCi/g) | | |
|---------------|-------------------------|-------------|---------|
| | Pu-239/240 (alpha spec) | | |
| Sample ID | Activity | Uncertainty | MDL |
| 04A-FUNST-003 | -0.00109 | 0.00489 | 0.00441 |
| 3 | 0.00122 | 0.00423 | 0.00284 |
| 7 | 0 | 0.00344 | 0.00283 |
| 8 | 0 | 0.00465 | 0.00383 |
| 9 | 0 | 0.00346 | 0.00285 |
| 12 | -0.00144 | 0.00646 | 0.00582 |
| 15 | 0.0046 | 0.00728 | 0.00463 |
| 16 | -0.00105 | 0.0047 | 0.00423 |

Abbreviations and Acronyms:

MDL – method detection limit

pCi/g – picocuries per gram

Pu-239 – plutonium-239

4.0 LABORATORY ANALYSIS

4.1 SAMPLE PREPARATION

Samples for radiological analysis were collected in the field by trained and qualified radiological technicians. When soil samples were collected in the field, they were first processed through a colander apparatus to eliminate foreign objects and large debris. If the samples were acceptable for processing, an adequate amount of the sample was then placed into the geometry used by the on-site laboratory for analysis. However, if, in the opinion of the field technician, the sample was saturated beyond 10 percent moisture content by weight (as may be indicated by a failure to pass material through the colander apparatus), then approximately four times the amount of sample needed for analysis was placed into a Ziploc® bag for subsequent drying by laboratory personnel.

The field technician who collected the sample turned the samples over to the on-site laboratory using the chain-of-custody (COC) procedure described in the SAP (TtEC 2012b). Each sample is verified to contain identical information on the sample container and the associated COC form when received at the laboratory.

Once the samples were received by the on-site laboratory, each sample was verified to contain less than 10 percent moisture content by weight when massed. Samples with moisture in excess of the 10 percent limit were dried in a laboratory oven. Once the moisture content was determined to be less than 10 percent, the sample was passed through consecutively smaller sieves, ending at a number 40, to screen for any foreign materials that may have been present.

An aliquot of the remaining materials was then placed and sealed in a 250-milliliter “tuna can” geometry necessary for analysis by the on-site screening laboratory team. Time-critical remediation decisions were based on the conservative results from the on-site screening gamma spectroscopy results. The Curtis and Tompkins laboratory analyzed the samples directly for ^{226}Ra using the EPA 901.1 MOD/DOE HASL 4.3.5.2 method and analysis of the 46.09 percent abundant ^{214}Bi 609.31 keV gamma energy peak in conjunction with a conservative in-growth correction factor based on the number of days the sample approached secular equilibrium after having been sealed in the tuna can geometry.

The final definitive data ^{226}Ra results were calculated and reported from the 46.09 percent abundant 609.31 keV gamma spectrum line of ^{214}Bi after an in-growth period of greater than 21 days to allow the ^{214}Bi to approach secular equilibrium with ^{226}Ra , or were conservatively calculated using the same ^{214}Bi gamma energy peak with an in-growth correction factor based on the number of days the sample approached secular equilibrium after having been sealed in the tuna can geometry. The definitive data are included in each SUPR.

4.2 GAMMA SPECTROSCOPY ANALYSIS

Gamma spectroscopy analyses were performed by Curtis and Tompkins. Curtis and Tompkins is a California Department of Public Health certified laboratory, as well as a DoD ELAP accredited laboratory.

Gamma spectroscopy analysis was performed using EG&G ORTEC® detector systems equipped with beryllium end caps (windows), which allowed for enhanced quantification of low-energy gammas (such as ²²⁶Ra). Hardware features included a high-purity germanium gamma photon detector supported by a multi-channel analyzer and analysis software. Instrument hardware was calibrated using a multi-energy National Institute of Standards and Technology traceable source ranging from 50 keV to 2.6 megaelectron volts. All results were reported in pCi/g.

Data reviews consisted of ensuring that 100 percent of the data comply with the method- and project-specific requirements as outlined in the SAP (TtEC 2012b). Quality assurance data reviews included checking for compliance with the required QC practices, SOPs, and method and project requirements.

Additionally, a review was conducted to ensure that the soil sample results for each ESU and trench unit appeared reasonable after a holistic analysis of all corresponding data, including gamma scan survey, gamma static surveys, previous soil sample results, and the potential variance in geological soil types within each ESU or trench unit, as applicable. Note that within each trench unit, it is possible (and oftentimes for deeper trenches, probable) that one or more distinct soil types may exist within one trench survey unit, based on the location of the trench unit and its relation to the overall HPNS layout, as the base was constructed in various phases over the years, utilizing numerous different material types in varying quantities. As such, these varying soil types typically exhibit NORM radionuclides in differing activity concentrations. Any data review that indicated soil sample results that could not be logically reconciled through trench unit specific survey and sample result data was subsequently further investigated by a visual inspection of the specific trench soil types, further radiological surveys and/or additional soil sample collection and analysis prior to submittal to RASO for a request for concurrence to backfill each specific trench survey unit.

The RASO reviewed the data prior to concurring on release of material, backfilling of trenches, or disposal as low-level radioactive waste.

4.3 GAMMA SPECTROSCOPY ANALYSIS FLAGS

The gamma vision software produces a report once the analysis is complete. Each report is typically eight pages long, with a summary provided on the last page. The summary reports are then presented for each sample in the individual SUPR. The summary reports also identify flags (or symbols) that may be associated with each radionuclide, if appropriate. These flags and their associated meanings are presented below and do not specify that the data are not valid:

- **U – Result is less than the sample Minimum Detectable Activity (MDA).** The activity calculation performed on the peaks for the isotope of concern yields a lower value than the calculation for the MDA. This identifies that a calculation was performed and the peaks were found, but the resulting activity was lower than the MDA.
- **b – Noncompliant.** The activity was less than the MDA and the MDA was above the Project MDA; the analyte was not indicated on the COC as a radionuclide of concern; therefore, corrective action or longer count time is not required.

4.4 TOTAL STRONTIUM/STRONTIUM-90 ANALYSIS

The off-site DoD ELAP accredited laboratory, TestAmerica St. Louis, determines total strontium and ^{90}Sr through separation and isotopic measurement. For soils, the strontium is transferred from the soil into a liquid matrix prior to precipitation as insoluble carbonate. Interferences from calcium and other radionuclides are removed by one or more precipitations of the strontium carrier as strontium nitrate. Samples with high dissolved solids can be precipitated as sulfates from an acid solution, eliminating most of the calcium interference. Diethylene triamine pentaacetic acid is added to the samples precipitated as sulfates to further remove interferences. Barium and radium are removed as chromate. The yttrium-90 daughter of ^{90}Sr is removed by a hydroxide precipitation step. The yttrium-90 daughter grows in again and is then separated with stable yttrium carrier as hydroxide and finally precipitated as oxalate and beta counted. Total strontium and ^{90}Sr are counted for beta particle activity by gas flow proportional counters.

Note that in most cases, ^{90}Sr was analyzed for total strontium, which includes ^{89}Sr and ^{90}Sr . If this total strontium result was less than the ^{90}Sr release criterion, this result was conservatively reported at the ^{90}Sr result. However, if the total strontium result was larger than the ^{90}Sr release criterion, the sample was further analyzed using the ^{90}Sr sample analysis procedure described above.

The results of total strontium/ ^{90}Sr analysis were reported in pCi/g and are included as an attachment to each SUPR. Any sample exhibiting ^{137}Cs activity greater than the release criterion was also analyzed for total strontium/ ^{90}Sr .

A minimum of 10 percent of samples were randomly chosen for ^{90}Sr analysis at TestAmerica St. Louis.

4.5 COUNTING UNCERTAINTY

Measurement of radioactivity has some degree of inherent uncertainty. The uncertainty quoted is the standard deviation of the average, obtained from the statistical uncertainties of the individual measurements. This uncertainty results from the combination of all possible inaccuracies in the measurement process, including such factors as the reading of the result, peak integration interpretation, peak background determination, the calibration of the measurement device, numerical rounding errors, and the random nature of radioactivity. Individual radioactivity

measurements are accompanied by a plus or minus (\pm) value, which is an uncertainty term known as either the two-sigma counting error or the total propagated analytical uncertainty.

Total propagated uncertainty includes both counting uncertainty and analytical uncertainty. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the counting uncertainty gives information on what the measurement might be if the same sample were counted again under identical conditions. The counting uncertainty implies that approximately 95 percent of the time, a recount of the same sample would give a value somewhere between the reported value minus the counting uncertainty and the reported value plus the counting uncertainty.

The uncertainty in the background is not as simple because the background is a calculated number. The background area uncertainty is the uncertainty in the channels used to calculate the end points of the background multiplied by the ratio of the number of channels in the peak to the number of channels used to calculate the background. For wide peaks and low counts per channel, there is high uncertainty in the calculated background.

4.6 DATA ASSESSMENT

Laboratory data were assessed to determine whether the objectives of the survey process were met. The assessment process consisted of four data phases: verification, validation, evaluation, and quality assessment. The assessment of HPNS laboratory data ensured the objective of the survey, final unrestricted release, was met.

4.6.1 Data Verification

Data verification ensured that the requirements were implemented as prescribed. Data verification activities included technical reviews of data and audits, as appropriate.

4.6.2 Data Validation

As stated in the SAP (TtEC 2012b), there are no standards for data validation of radiological analyses. Therefore, guidance documents and modified functional guidelines were used in validation of radiological data. Data not meeting method and/or SAP specifications were flagged as estimated or rejected.

Relative percent difference requirements for duplicate samples for the DoD ELAP accredited laboratories are provided in Worksheet 28.1 of the SAP (TtEC 2012b).

4.6.3 Data Evaluation

Radiochemical and laboratory data were evaluated prior to submittal to the RASO. The evaluation of data was based on method requirements and results of QC checks, the level of contamination of method blanks and method spikes (as appropriate), and the overall indication of interference due to contamination. The data qualifiers, if used, were listed at the bottom of the data report.

4.6.4 Data Quality Assessment

Data quality assessment (DQA) is a scientific and statistical evaluation that indicates whether the data are of the right type, quality, and quantity to support their intended use. DQA provides the assessment needed to decide if the planning objectives were met. All data presented in the SUPRs were subject to the DQA process, and the data were determined suitable for use.

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5.0 STATISTICAL TESTS

As stated in Section 8.2.2.1 of MARSSIM (DoD et al. 2000), there is no need to conduct statistical tests when all sample results are less than the release criteria. Because all FSS sample results for the SUPRs were less than the release criteria, no statistical tests were included in the SUPRs. However, this section describes the process by which the sampling density was determined such that statistical testing, if necessary, would be sufficient.

5.1 DECISION ERRORS

There are two types of decision errors that were used when performing the statistical tests outlined in MARSSIM (DoD et al. 2000). The first type of decision error, called a Type I error, occurs when the null hypothesis is rejected when it is actually true. This type of error is sometimes called a “false positive.” The probability of a Type I error is denoted by an α . The Type I error is often referred to as the significance level or size of the test.

The second type of decision error, called a Type II error, occurs when the null hypothesis is not rejected when it is actually false. This type of error is sometimes called a “false negative.” The probability of a Type II error is denoted by a β . The power of a statistical test is defined as the probability of rejecting the null hypothesis when it is actually false. It is numerically equal to $1 - \beta$, where β is the Type II error rate.

Each survey was designed to limit Type I and Type II errors to a maximum probability of 5 percent. It was important to minimize the chances of concluding that a survey unit met the release criteria (reject the null hypothesis) when it actually exceeded the limits (Type I error), and concluding that a survey unit exceeded the release criteria (accept the null hypothesis) when it actually met the limits (Type II error).

5.2 WILCOXON RANK-SUM TEST

The Wilcoxon Rank-Sum (WRS) test is designed to test a hypothesis about the location of a population distribution. It is most often used to test the hypothesis about a population median and often involves the use of matched pairs. For example, reference area and survey unit data were tested for a median difference of zero. This test is also a nonparametric test that may be used when it is only necessary, or possible, to know if observed differences between two conditions were significant. The WRS test is structured to denote a change in magnitude, as opposed to any attempt at the quantitative measurement. Per Section 2.5.1.2 of MARSSIM (DoD et al. 2000), the WRS test is the recommended statistical test for comparison of survey unit radionuclide concentrations with background radionuclide concentrations. Although the WRS test was not conducted for the SUPRs because the results for all survey units were less than the release criteria, the number of sampling points was calculated to ensure that sufficient sample results from the survey unit areas

were available for statistical comparison had all FSS results not all been lower than each release criterion.

5.2.1 Determining the Numbers of Data Points for the WRS Test

Since the ROCs were present in background, N is calculated in the manner specified for the WRS test using Equation 5-1:

Equation 5-1

$$N = \left(\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2} \right) (1.2)$$

Where:

- $Z_{1-\alpha}$ = 1.645 Type I decision error level
- $Z_{1-\beta}$ = 1.645 Type II decision error level
- P_r = 0.997658 random measurement probability
(from Table 5.1 in MARSSIM [NUREG-1575; DoD et al. 2000])
- (1.2) = 20% increase in number of samples over the minimum

The variable used to calculate N not already specified in the Basewide Radiological Management Plan (TtEC 2012a) was the random measurement probability P_r . P_r in Equation 5-1 above is based on the relative shift. The relative shift is equal to Δ/σ , where Δ was equal to the release criterion minus the lower boundary of the gray region (LBGR), and σ was an estimate of the standard deviation of the measured values in a survey unit. The LBGR was the net median concentration of the contaminant in the survey unit. When this value was unknown, half the value of the Derived Concentration Guideline Limit corresponding to a total effective dose equivalent of 25 mrem/y to a member of the critical group was used as the LBGR, as suggested in MARSSIM (DoD et al. 2000). Likewise, σ was assigned the value of the standard deviation of the measurement values in the reference area.

Using Equation 5-2 below, the value for Δ was derived by converting the release criterion from pCi/g to counts per second (cps). To perform this conversion, an arbitrary concentration of ^{226}Ra is divided by the associated exposure rate produced by this concentration of ^{226}Ra . The resulting number was then divided by the average net cps per microrentgen per hour ($\mu\text{R/h}$) for the detectors on the towed array. Once this number was derived, the release criterion of 1.0 pCi/g for ^{226}Ra was divided by this number.

Equation 5-2

$$RC \text{ in cpm} = \frac{RC}{AC / ER * 1 / CR}$$

Where:

RC = release criterion (pCi/g)
 AC = arbitrary concentration of ^{226}Ra (pCi/g)
 ER = exposure rate for 1 pCi/g ^{226}Ra calculated by Microshield®
 CR = counts per second per $\mu\text{R/h}$ for the detector

Where:

RC = 1.0
 AC = 1
 ER = 0.6984
 CR = 436

The values used for these parameters to determine a P_r were 304 cps for the release criterion. Taking half of this value, 152 cps for Δ , and using 30 cps for σ , N was calculated as nine samples when using Equation 5-1. To obtain reasonable assurance that any small areas of elevated residual radioactivity were not missed during the survey, the total number of samples was increased by a factor of two, for a total of 18 samples in each survey unit.

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6.0 DOSE MODELING

The intent of a SUPR is to achieve unrestricted release for the associated survey unit. In doing so, the most conservative approach was used to model the area using the most current version of RESRAD. The default residential farmer scenario was used with only two minor changes. The first is that the actual surface area of the trench unit was used (in square meters). The second is that modeling was performed using the mean concentrations of ^{137}Cs , ^{226}Ra (with the lead-210 daughter), and ^{90}Sr using the actual activity and replacing it with the MDA value if the reported activity was less than the MDA. The activity used to model for ^{226}Ra was based on the isotopic net concentration (survey unit mean isotopic concentration minus background mean isotopic concentration). No background is subtracted from the ^{137}Cs or ^{90}Sr values, as these radionuclides are not naturally occurring or expected at drain piping depths from global fallout from nuclear weapons testing.

The default parameters included external and inhalation exposures and exposure from the following ingestion pathways: drinking water, food grown with contaminated irrigation water, food grown on contaminated soil, fish, and inadvertent ingestion of soil. Land-based foods considered were leafy vegetables, root vegetables, fruit, grain, beef, poultry, milk, and eggs. Animal feeds included fresh forage, as well as stored grain and hay. This was the most conservative scenario as it assumed that persons living on the site can use the land for any purpose without land use restrictions.

If none of the concentrations for the ROCs for the specific survey unit were greater than zero, the net dose and increased health risk for the survey unit were expected to be negligible, and no further modeling was determined to be reasonable or prudent.

The final dose and health risk modeling summary, if needed, will be included in each SUPR. Demonstration of both a net residual dose of less than 25 millirems per year and a net increased health risk in the range of 10^{-4} to 10^{-6} to the average member of the critical group (or member of the public) will be considered sufficient for unrestricted release of the survey unit.

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7.0 RECOMMENDATION OF FINAL UNRESTRICTED RELEASE

A SUPR will be prepared for each survey unit with recommendations for free release. Each SUPR will provide general background information about the trench unit and associated ESU(s) that are part of the survey unit package. Any exceptions to the ROCs will be addressed in each SUPR.

A discussion of the FSS will include the activities performed for the trench unit and each ESU or import fill that was used for backfill. The discussion will include results of the soil samples. Gamma scan data will be provided as attachments in each SUPR.

The version of RESRAD used and the results of the dose and risk modeling will be provided as an attachment and discussed in each SUPR.

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8.0 REFERENCES

- DoD (Department of Defense), Department of Energy, Nuclear Regulatory Commission, and U.S. Environmental Protection Agency. 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). NUREG-1575. August.
- DON (Department of the Navy). 2006. Final Base-wide Radiological Removal Action, Action Memorandum – Revision 2006, Hunters Point Shipyard, San Francisco, California.
- NAVSEA (Naval Sea Systems Command). 2004. Final Historical Radiological Assessment, Volume II.
- NCRP (National Council on Radiation Protection and Measurements). 1993. The National Council on Radiation Protection and Measurements, Report Number 116.
- NRC (Nuclear Regulatory Commission). 1997. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions Guide (NUREG-1507).
- . 1998. Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey Guide (NUREG 1505).
- TtEC (Tetra Tech EC, Inc.). 2008. Final Project Work Plan, Revision 3. Base-wide Storm Drain and Sanitary Sewer Removal, Hunters Point Shipyard, San Francisco, California. November 30.
- . 2011. Final Execution Plan, Revision 1, Attachment 1: Sampling and Analysis Plan, Basewide Radiological Support, Hunters Point Naval Shipyard, San Francisco, California. December 20.
- . 2012a. Final Basewide Radiological Management Plan. Hunters Point Naval Shipyard, San Francisco, California. February 3.
- . 2012b. Final Execution Plan, Attachment 1: Sampling and Analysis Plan, Parcel C Phase II Radiological Remediation and Support, Hunters Point Naval Shipyard, San Francisco, California. November.

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ATTACHMENT 1

IMPORT FILL MATERIAL

SAMPLE RESULTS

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MILLS PENINSULA BACKFILL

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Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-001 | Received: | 03/25/11 |
| Lab ID: | 244072-001 | Prepared: | 02/19/07 07:30 |
| Matrix: | Soil | Analyzed: | 01/10/13 07:59 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 294 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 07:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | -0.0146 U | 0.168 | 0.137 | 0.9 |
| Bismuth-212 | 0.828 | 0.428 | 0.182 | |
| Bismuth-214 | 0.545 | 0.0964 | 0.0313 | |
| Cesium-137 | 0.0270 | 0.0334 | 0.0246 | 0.07 |
| Cobalt-60 | 0 U b | 0.0155 | 0.0973 | 0.03 |
| Europium-152 | 0.0279 U | 0.0808 | 0.0779 | 0.1 |
| Europium-154 | 0.0399 U b | 0.0946 | 0.261 | 0.2 |
| Lead-212 | 0.473 | 0.0738 | 0.0343 | |
| Lead-214 | 0.509 | 0.0931 | 0.0524 | |
| Potassium-40 | 8.28 | 0.988 | 0.315 | |
| Protactinium-234 | -0.0146 U | 0.0495 | 0.0841 | |
| Radium-226 (By Bismuth-214) | 0.545 | 0.0964 | 0.0313 | 0.2 |
| Thallium-208 | 0.184 | 0.0502 | 0.0224 | |
| Thorium-232 (By Actinium-228) | 0.550 | 0.117 | 0.0625 | 0.9 |
| Thorium-234 | 0.886 U | 0.454 | 1.12 | |
| Uranium-235 | 0.0679 U | 0.0307 | 0.152 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-002 | Received: | 03/25/11 |
| Lab ID: | 244072-002 | Prepared: | 02/19/07 07:40 |
| Matrix: | Soil | Analyzed: | 01/10/13 08:55 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 297 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 07:40 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0 U | 0.117 | 0.146 | 0.9 |
| Bismuth-212 | 0.623 | 0.471 | 0.283 | |
| Bismuth-214 | 0.491 | 0.106 | 0.0434 | |
| Cesium-137 | 0.00692 U | 0.0308 | 0.0246 | 0.07 |
| Cobalt-60 | 0.0128 U b | 0.0537 | 0.0420 | 0.03 |
| Europium-152 | 0.0541 U | 0.0730 | 0.0691 | 0.1 |
| Europium-154 | -0.121 U b | 0.376 | 0.296 | 0.2 |
| Lead-212 | 0.453 | 0.0722 | 0.0344 | |
| Lead-214 | 0.484 | 0.0821 | 0.0447 | |
| Potassium-40 | 8.23 | 0.954 | 0.269 | |
| Protactinium-234 | 0.0355 U | 0.0987 | 0.0873 | |
| Radium-226 (By Bismuth-214) | 0.491 | 0.106 | 0.0434 | 0.2 |
| Thallium-208 | 0.149 | 0.0392 | 0.0160 | |
| Thorium-232 (By Actinium-228) | 0.473 | 0.114 | 0.0677 | 0.9 |
| Thorium-234 | 0.638 U | 0.708 | 1.06 | |
| Uranium-235 | 0.0601 U | 0.0467 | 0.133 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-003 | Received: | 03/25/11 |
| Lab ID: | 244072-003 | Prepared: | 02/19/07 07:50 |
| Matrix: | Soil | Analyzed: | 01/10/13 08:56 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 318 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 07:50 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.0881 U | 0.176 | 0.140 | 0.9 |
| Bismuth-212 | 0.547 | 0.412 | 0.254 | |
| Bismuth-214 | 0.591 | 0.0986 | 0.0346 | |
| Cesium-137 | 0.0151 U | 0.0307 | 0.0237 | 0.07 |
| Cobalt-60 | 0.0176 U b | 0.0486 | 0.0369 | 0.03 |
| Europium-152 | 0.0449 U | 0.0617 | 0.0753 | 0.1 |
| Europium-154 | 0.104 U b | 0.186 | 0.242 | 0.2 |
| Lead-212 | 0.441 | 0.0733 | 0.0362 | |
| Lead-214 | 0.479 | 0.0804 | 0.0395 | |
| Potassium-40 | 8.82 | 0.980 | 0.295 | |
| Protactinium-234 | 0.0707 U | 0.0984 | 0.0798 | |
| Radium-226 (By Bismuth-214) | 0.591 | 0.0986 | 0.0346 | 0.2 |
| Thallium-208 | 0.136 | 0.0385 | 0.0177 | |
| Thorium-232 (By Actinium-228) | 0.401 | 0.128 | 0.0668 | 0.9 |
| Thorium-234 | 1.59 | 1.28 | 0.954 | |
| Uranium-235 | 0.0663 U | 0.0442 | 0.140 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-004 | Received: | 03/25/11 |
| Lab ID: | 244072-004 | Prepared: | 02/19/07 08:00 |
| Matrix: | Soil | Analyzed: | 01/10/13 09:44 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 301 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:00 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|--------|--------|-------------|
| Americium-241 | 0.00670 U | 0.141 | 0.116 | 0.9 |
| Bismuth-212 | 0.348 | 0.525 | 0.330 | |
| Bismuth-214 | 0.530 | 0.0948 | 0.0328 | |
| Cesium-137 | 0.00747 U | 0.0259 | 0.0204 | 0.07 |
| Cobalt-60 | 0.000212 U b | 0.0390 | 0.0321 | 0.03 |
| Europium-152 | 0.0409 U | 0.0730 | 0.0695 | 0.1 |
| Europium-154 | 0.0301 U b | 0.0751 | 0.226 | 0.2 |
| Lead-212 | 0.443 | 0.0751 | 0.0369 | |
| Lead-214 | 0.549 | 0.105 | 0.0482 | |
| Potassium-40 | 8.79 | 0.977 | 0.266 | |
| Protactinium-234 | 0.0376 U | 0.103 | 0.0823 | |
| Radium-226 (By Bismuth-214) | 0.530 | 0.0948 | 0.0328 | 0.2 |
| Thallium-208 | 0.152 | 0.0435 | 0.0192 | |
| Thorium-232 (By Actinium-228) | 0.515 | 0.128 | 0.0614 | 0.9 |
| Thorium-234 | 0.630 U | 0.540 | 1.13 | |
| Uranium-235 | 0.0549 U | 0.0276 | 0.131 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-005 | Received: | 03/25/11 |
| Lab ID: | 244072-005 | Prepared: | 02/19/07 08:10 |
| Matrix: | Soil | Analyzed: | 01/10/13 09:46 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 280 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:10 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.126 | 0.150 | 0.114 | 0.9 |
| Bismuth-212 | 0.367 | 0.354 | 0.249 | |
| Bismuth-214 | 0.395 | 0.0889 | 0.0420 | |
| Cesium-137 | 0 U | 0.0374 | 0.0386 | 0.07 |
| Cobalt-60 | -0.0112 U b | 0.0724 | 0.0582 | 0.03 |
| Europium-152 | 0.0528 U | 0.0835 | 0.0864 | 0.1 |
| Europium-154 | 0.0460 U b | 0.0773 | 0.228 | 0.2 |
| Lead-212 | 0.412 | 0.0847 | 0.0457 | |
| Lead-214 | 0.615 | 0.112 | 0.0507 | |
| Potassium-40 | 7.70 | 0.974 | 0.347 | |
| Protactinium-234 | 0.0356 U | 0.0899 | 0.0952 | |
| Radium-226 (By Bismuth-214) | 0.395 | 0.0889 | 0.0420 | 0.2 |
| Thallium-208 | 0.179 | 0.0492 | 0.0214 | |
| Thorium-232 (By Actinium-228) | 0.546 | 0.114 | 0.0736 | 0.9 |
| Thorium-234 | 0.504 U | 1.29 | 1.03 | |
| Uranium-235 | 0.143 U | 0.174 | 0.157 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-006 | Received: | 03/25/11 |
| Lab ID: | 244072-006 | Prepared: | 02/19/07 08:20 |
| Matrix: | Soil | Analyzed: | 01/10/13 10:40 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 282 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:20 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.0878 U | 0.179 | 0.143 | 0.9 |
| Bismuth-212 | 0.630 | 0.441 | 0.296 | |
| Bismuth-214 | 0.535 | 0.107 | 0.0396 | |
| Cesium-137 | 0.0270 | 0.0300 | 0.0212 | 0.07 |
| Cobalt-60 | -0.0187 U b | 0.0658 | 0.0514 | 0.03 |
| Europium-152 | 0.0520 U | 0.0705 | 0.0715 | 0.1 |
| Europium-154 | 0.0683 U b | 0.128 | 0.245 | 0.2 |
| Lead-212 | 0.421 | 0.0770 | 0.0396 | |
| Lead-214 | 0.556 | 0.115 | 0.0545 | |
| Potassium-40 | 8.12 | 1.04 | 0.360 | |
| Protactinium-234 | 0.0577 U | 0.105 | 0.0951 | |
| Radium-226 (By Bismuth-214) | 0.535 | 0.107 | 0.0396 | 0.2 |
| Thallium-208 | 0.214 | 0.0503 | 0.0209 | |
| Thorium-232 (By Actinium-228) | 0.598 | 0.119 | 0.0556 | 0.9 |
| Thorium-234 | 0.476 U | 0.422 | 1.26 | |
| Uranium-235 | 0.185 | 0.167 | 0.125 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-007 | Received: | 03/25/11 |
| Lab ID: | 244072-007 | Prepared: | 02/19/07 08:30 |
| Matrix: | Soil | Analyzed: | 01/10/13 10:42 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 315 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | -0.00659 U | 0.157 | 0.129 | 0.9 |
| Bismuth-212 | 0.758 | 0.367 | 0.171 | |
| Bismuth-214 | 0.489 | 0.0974 | 0.0356 | |
| Cesium-137 | -0.00724 U | 0.0318 | 0.0255 | 0.07 |
| Cobalt-60 | -0.0206 U b | 0.0703 | 0.0554 | 0.03 |
| Europium-152 | 0.0258 U | 0.0711 | 0.0792 | 0.1 |
| Europium-154 | 0.0124 U b | 0.0277 | 0.269 | 0.2 |
| Lead-212 | 0.401 | 0.0739 | 0.0372 | |
| Lead-214 | 0.495 | 0.0897 | 0.0423 | |
| Potassium-40 | 9.41 | 0.976 | 0.258 | |
| Protactinium-234 | 0.0270 U | 0.0987 | 0.0917 | |
| Radium-226 (By Bismuth-214) | 0.489 | 0.0974 | 0.0356 | 0.2 |
| Thallium-208 | 0.117 | 0.0400 | 0.0197 | |
| Thorium-232 (By Actinium-228) | 0.485 | 0.126 | 0.0638 | 0.9 |
| Thorium-234 | 0.270 U | 0.435 | 1.07 | |
| Uranium-235 | 0.0421 U | 0.0260 | 0.149 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-008 | Received: | 03/25/11 |
| Lab ID: | 244072-008 | Prepared: | 02/19/07 08:40 |
| Matrix: | Soil | Analyzed: | 01/10/13 11:28 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 317 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:40 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.00955 U | 0.140 | 0.115 | 0.9 |
| Bismuth-212 | 0.540 | 0.419 | 0.241 | |
| Bismuth-214 | 0.382 | 0.0778 | 0.0243 | |
| Cesium-137 | 0.0107 U | 0.0302 | 0.0237 | 0.07 |
| Cobalt-60 | 0.0280 U b | 0.0600 | 0.0453 | 0.03 |
| Europium-152 | 0.0233 U | 0.0571 | 0.0704 | 0.1 |
| Europium-154 | 0.0241 U b | 0.318 | 0.259 | 0.2 |
| Lead-212 | 0.414 | 0.0706 | 0.0339 | |
| Lead-214 | 0.367 | 0.0996 | 0.0530 | |
| Potassium-40 | 9.99 | 1.08 | 0.328 | |
| Protactinium-234 | 0.0849 U | 0.112 | 0.0879 | |
| Radium-226 (By Bismuth-214) | 0.382 | 0.0778 | 0.0243 | 0.2 |
| Thallium-208 | 0.146 | 0.0387 | 0.0166 | |
| Thorium-232 (By Actinium-228) | 0.487 | 0.120 | 0.0269 | 0.9 |
| Thorium-234 | 0.266 U | 1.21 | 0.982 | |
| Uranium-235 | 0.0348 U | 0.0312 | 0.150 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-009 | Received: | 03/25/11 |
| Lab ID: | 244072-009 | Prepared: | 02/19/07 08:50 |
| Matrix: | Soil | Analyzed: | 01/10/13 11:29 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 359 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 08:50 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.0250 U | 0.144 | 0.117 | 0.9 |
| Bismuth-212 | 0.596 | 0.298 | 0.130 | |
| Bismuth-214 | 0.364 | 0.0772 | 0.0270 | |
| Cesium-137 | 0 U | 0.0179 | 0.0332 | 0.07 |
| Cobalt-60 | 0.00344 U b | 0.0285 | 0.0357 | 0.03 |
| Europium-152 | 0.0671 | 0.0700 | 0.0619 | 0.1 |
| Europium-154 | 0.0287 U b | 0.290 | 0.235 | 0.2 |
| Lead-212 | 0.298 | 0.0658 | 0.0352 | |
| Lead-214 | 0.382 | 0.0831 | 0.0385 | |
| Potassium-40 | 8.01 | 0.886 | 0.273 | |
| Protactinium-234 | 0.0512 U | 0.0607 | 0.0789 | |
| Radium-226 (By Bismuth-214) | 0.364 | 0.0772 | 0.0270 | 0.2 |
| Thallium-208 | 0.108 | 0.0337 | 0.0164 | |
| Thorium-232 (By Actinium-228) | 0.287 | 0.0962 | 0.0647 | 0.9 |
| Thorium-234 | -0.00227 U | 1.19 | 0.982 | |
| Uranium-235 | 0.0518 U | 0.0320 | 0.126 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-010 | Received: | 03/25/11 |
| Lab ID: | 244072-010 | Prepared: | 02/19/07 09:00 |
| Matrix: | Soil | Analyzed: | 01/10/13 15:30 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 348 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:00 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | -0.0340 U | 0.141 | 0.114 | 0.9 |
| Bismuth-212 | 0.277 | 0.493 | 0.224 | |
| Bismuth-214 | 0.327 | 0.0770 | 0.0309 | |
| Cesium-137 | 0.00644 U | 0.0206 | 0.0161 | 0.07 |
| Cobalt-60 | 0.00634 U b | 0.0487 | 0.0392 | 0.03 |
| Europium-152 | 0.0147 U | 0.0924 | 0.0565 | 0.1 |
| Europium-154 | 0.0388 U | 0.104 | 0.181 | 0.2 |
| Lead-212 | 0.333 | 0.0613 | 0.0312 | |
| Lead-214 | 0.406 | 0.0813 | 0.0405 | |
| Potassium-40 | 8.51 | 0.930 | 0.284 | |
| Protactinium-234 | 0.0652 | 0.0779 | 0.0642 | |
| Radium-226 (By Bismuth-214) | 0.327 | 0.0770 | 0.0309 | 0.2 |
| Thallium-208 | 0.121 | 0.0415 | 0.0192 | |
| Thorium-232 (By Actinium-228) | 0.438 | 0.128 | 0.0498 | 0.9 |
| Thorium-234 | 0.159 U | 0.172 | 0.798 | |
| Uranium-235 | 0.0208 U | 0.0267 | 0.153 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-011 | Received: | 03/25/11 |
| Lab ID: | 244072-011 | Prepared: | 02/19/07 09:10 |
| Matrix: | Soil | Analyzed: | 01/10/13 16:21 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 312 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:10 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|--------|-------------|
| Americium-241 | 0.0368 U | 0.159 | 0.128 | 0.9 |
| Bismuth-212 | 0.670 | 0.392 | 0.174 | |
| Bismuth-214 | 0.412 | 0.0898 | 0.0333 | |
| Cesium-137 | -0.00857 U | 0.0345 | 0.0276 | 0.07 |
| Cobalt-60 | -0.00325 U b | 0.00932 | 0.0516 | 0.03 |
| Europium-152 | 0.0234 U | 0.0619 | 0.0732 | 0.1 |
| Europium-154 | 0.0320 U b | 0.0664 | 0.296 | 0.2 |
| Lead-212 | 0.408 | 0.0732 | 0.0381 | |
| Lead-214 | 0.498 | 0.0977 | 0.0452 | |
| Potassium-40 | 9.67 | 0.994 | 0.261 | |
| Protactinium-234 | -0.0129 U | 0.0190 | 0.0863 | |
| Radium-226 (By Bismuth-214) | 0.412 | 0.0898 | 0.0333 | 0.2 |
| Thallium-208 | 0.145 | 0.0414 | 0.0190 | |
| Thorium-232 (By Actinium-228) | 0.466 | 0.109 | 0.0264 | 0.9 |
| Thorium-234 | 0.130 U | 0.280 | 1.07 | |
| Uranium-235 | 0.0450 U | 0.0393 | 0.130 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-012 | Received: | 03/25/11 |
| Lab ID: | 244072-012 | Prepared: | 02/19/07 09:20 |
| Matrix: | Soil | Analyzed: | 01/11/13 07:26 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 321 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:20 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | -0.0817 U | 0.182 | 0.146 | 0.9 |
| Bismuth-212 | 0.638 | 0.332 | 0.168 | |
| Bismuth-214 | 0.425 | 0.0855 | 0.0324 | |
| Cesium-137 | 0.00250 U | 0.0263 | 0.0214 | 0.07 |
| Cobalt-60 | 0.0293 U b | 0.0530 | 0.0388 | 0.03 |
| Europium-152 | 0.00967 U | 0.0243 | 0.0792 | 0.1 |
| Europium-154 | 0.0587 U b | 0.129 | 0.223 | 0.2 |
| Lead-212 | 0.345 | 0.0741 | 0.0400 | |
| Lead-214 | 0.494 | 0.0797 | 0.0384 | |
| Potassium-40 | 8.38 | 0.992 | 0.328 | |
| Protactinium-234 | 0.0465 U | 0.0707 | 0.0730 | |
| Radium-226 (By Bismuth-214) | 0.425 | 0.0855 | 0.0324 | 0.2 |
| Thallium-208 | 0.167 | 0.0408 | 0.0179 | |
| Thorium-232 (By Actinium-228) | 0.473 | 0.0979 | 0.0725 | 0.9 |
| Thorium-234 | 0.384 U | 0.300 | 1.17 | |
| Uranium-235 | 0.0353 U | 0.0295 | 0.142 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-013 | Received: | 03/25/11 |
| Lab ID: | 244072-013 | Prepared: | 02/19/07 09:30 |
| Matrix: | Soil | Analyzed: | 01/11/13 08:19 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 302 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|--------|--------|-------------|
| Americium-241 | -0.0626 U | 0.176 | 0.141 | 0.9 |
| Bismuth-212 | 0.406 | 0.355 | 0.244 | |
| Bismuth-214 | 0.374 | 0.0787 | 0.0275 | |
| Cesium-137 | 0.00204 U | 0.0286 | 0.0234 | 0.07 |
| Cobalt-60 | -0.00385 U b | 0.0544 | 0.0442 | 0.03 |
| Europium-152 | 0.0480 U | 0.0841 | 0.0848 | 0.1 |
| Europium-154 | 0.0552 U b | 0.0769 | 0.332 | 0.2 |
| Lead-212 | 0.446 | 0.0749 | 0.0373 | |
| Lead-214 | 0.417 | 0.0848 | 0.0421 | |
| Potassium-40 | 9.69 | 1.01 | 0.270 | |
| Protactinium-234 | 0.0346 U | 0.0769 | 0.0777 | |
| Radium-226 (By Bismuth-214) | 0.374 | 0.0787 | 0.0275 | 0.2 |
| Thallium-208 | 0.157 | 0.0416 | 0.0174 | |
| Thorium-232 (By Actinium-228) | 0.502 | 0.127 | 0.0650 | 0.9 |
| Thorium-234 | 0.306 U | 1.45 | 1.18 | |
| Uranium-235 | 0.0456 U | 0.0394 | 0.126 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-014 | Received: | 03/25/11 |
| Lab ID: | 244072-014 | Prepared: | 02/19/07 09:40 |
| Matrix: | Soil | Analyzed: | 01/11/13 09:57 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 340 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:40 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.00655 U | 0.129 | 0.106 | 0.9 |
| Bismuth-212 | 0.394 | 0.348 | 0.244 | |
| Bismuth-214 | 0.429 | 0.0831 | 0.0306 | |
| Cesium-137 | 0.00533 U | 0.0256 | 0.0204 | 0.07 |
| Cobalt-60 | 0.0110 U b | 0.0173 | 0.0370 | 0.03 |
| Europium-152 | 0.0291 U | 0.0754 | 0.0584 | 0.1 |
| Europium-154 | 0.0416 U | 0.0508 | 0.188 | 0.2 |
| Lead-212 | 0.326 | 0.0624 | 0.0330 | |
| Lead-214 | 0.342 | 0.0847 | 0.0457 | |
| Potassium-40 | 8.67 | 0.939 | 0.278 | |
| Protactinium-234 | 0.0186 U | 0.0772 | 0.0768 | |
| Radium-226 (By Bismuth-214) | 0.429 | 0.0831 | 0.0306 | 0.2 |
| Thallium-208 | 0.115 | 0.0353 | 0.0175 | |
| Thorium-232 (By Actinium-228) | 0.406 | 0.0975 | 0.0302 | 0.9 |
| Thorium-234 | 0.556 U | 0.464 | 0.925 | |
| Uranium-235 | 0.0543 U | 0.0450 | 0.117 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-015 | Received: | 03/25/11 |
| Lab ID: | 244072-015 | Prepared: | 02/19/07 09:50 |
| Matrix: | Soil | Analyzed: | 01/11/13 10:54 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 295 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 09:50 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.115 U | 0.159 | 0.123 | 0.9 |
| Bismuth-212 | 0.412 | 0.504 | 0.275 | |
| Bismuth-214 | 0.418 | 0.0895 | 0.0349 | |
| Cesium-137 | -0.00571 U | 0.0291 | 0.0233 | 0.07 |
| Cobalt-60 | -0.0113 U b | 0.0598 | 0.0476 | 0.03 |
| Europium-152 | 0.0222 U | 0.0445 | 0.0780 | 0.1 |
| Europium-154 | -0.0773 U b | 0.340 | 0.271 | 0.2 |
| Lead-212 | 0.448 | 0.0798 | 0.0397 | |
| Lead-214 | 0.517 | 0.0991 | 0.0478 | |
| Potassium-40 | 8.79 | 1.03 | 0.334 | |
| Protactinium-234 | 0.00374 U | 0.0105 | 0.0979 | |
| Radium-226 (By Bismuth-214) | 0.418 | 0.0895 | 0.0349 | 0.2 |
| Thallium-208 | 0.174 | 0.0429 | 0.0188 | |
| Thorium-232 (By Actinium-228) | 0.451 | 0.118 | 0.0707 | 0.9 |
| Thorium-234 | 0.676 U | 0.670 | 0.993 | |
| Uranium-235 | 0.0586 U | 0.0480 | 0.141 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-016 | Received: | 03/25/11 |
| Lab ID: | 244072-016 | Prepared: | 02/19/07 10:00 |
| Matrix: | Soil | Analyzed: | 01/11/13 12:35 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 302 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 10:00 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.0477 U | 0.174 | 0.141 | 0.9 |
| Bismuth-212 | 1.03 | 0.399 | 0.162 | |
| Bismuth-214 | 0.520 | 0.0938 | 0.0300 | |
| Cesium-137 | -0.00896 U | 0.0366 | 0.0293 | 0.07 |
| Cobalt-60 | -0.0165 U b | 0.0675 | 0.0534 | 0.03 |
| Europium-152 | 0.114 | 0.131 | 0.0728 | 0.1 |
| Europium-154 | -0.0470 U b | 0.301 | 0.242 | 0.2 |
| Lead-212 | 0.511 | 0.0765 | 0.0370 | |
| Lead-214 | 0.580 | 0.105 | 0.0455 | |
| Potassium-40 | 10.5 | 1.07 | 0.290 | |
| Protactinium-234 | -0.000488 U | 0.105 | 0.0866 | |
| Radium-226 (By Bismuth-214) | 0.520 | 0.0938 | 0.0300 | 0.2 |
| Thallium-208 | 0.155 | 0.0454 | 0.0222 | |
| Thorium-232 (By Actinium-228) | 0.523 | 0.119 | 0.0378 | 0.9 |
| Thorium-234 | 1.06 U | 0.713 | 1.13 | |
| Uranium-235 | 0.0577 U | 0.0313 | 0.141 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-017 | Received: | 03/25/11 |
| Lab ID: | 244072-017 | Prepared: | 02/19/07 10:10 |
| Matrix: | Soil | Analyzed: | 01/11/13 13:42 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 284 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 10:10 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | -0.0207 U | 0.147 | 0.120 | 0.9 |
| Bismuth-212 | 0.342 | 0.385 | 0.278 | |
| Bismuth-214 | 0.502 | 0.0938 | 0.0293 | |
| Cesium-137 | 0.0203 U | 0.0295 | 0.0217 | 0.07 |
| Cobalt-60 | 0 U b | 0.0114 | 0.0705 | 0.03 |
| Europium-152 | 0.0885 | 0.132 | 0.0694 | 0.1 |
| Europium-154 | 0.0163 U b | 0.0841 | 0.241 | 0.2 |
| Lead-212 | 0.414 | 0.0737 | 0.0370 | |
| Lead-214 | 0.517 | 0.106 | 0.0532 | |
| Potassium-40 | 7.67 | 1.02 | 0.363 | |
| Protactinium-234 | 0.0648 U | 0.0826 | 0.0680 | |
| Radium-226 (By Bismuth-214) | 0.502 | 0.0938 | 0.0293 | 0.2 |
| Thallium-208 | 0.181 | 0.0413 | 0.0153 | |
| Thorium-232 (By Actinium-228) | 0.547 | 0.111 | 0.0535 | 0.9 |
| Thorium-234 | 0.550 U | 0.716 | 1.16 | |
| Uranium-235 | 0.0570 U | 0.0391 | 0.155 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-018 | Received: | 03/25/11 |
| Lab ID: | 244072-018 | Prepared: | 02/19/07 10:20 |
| Matrix: | Soil | Analyzed: | 01/11/13 15:46 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 287 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196775 | Uncert. Units: | pCi/g |
| Sampled: | 02/19/07 10:20 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | -0.0225 U | 0.174 | 0.142 | 0.9 |
| Bismuth-212 | 0.542 | 0.552 | 0.277 | |
| Bismuth-214 | 0.518 | 0.102 | 0.0379 | |
| Cesium-137 | -0.00166 U | 0.0319 | 0.0261 | 0.07 |
| Cobalt-60 | 0 U b | 0.0115 | 0.0504 | 0.03 |
| Europium-152 | 0.0213 U | 0.0702 | 0.0780 | 0.1 |
| Europium-154 | 0.0330 U | 0.0656 | 0.0596 | 0.2 |
| Lead-212 | 0.397 | 0.0788 | 0.0430 | |
| Lead-214 | 0.572 | 0.0921 | 0.0507 | |
| Potassium-40 | 8.28 | 1.02 | 0.323 | |
| Protactinium-234 | 0.0448 U | 0.110 | 0.0938 | |
| Radium-226 (By Bismuth-214) | 0.518 | 0.102 | 0.0379 | 0.2 |
| Thallium-208 | 0.165 | 0.0436 | 0.0178 | |
| Thorium-232 (By Actinium-228) | 0.667 | 0.158 | 0.0412 | 0.9 |
| Thorium-234 | 0.748 U | 0.734 | 1.18 | |
| Uranium-235 | 0.0605 U | 0.0371 | 0.140 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Batch QC Report

| Gamma Radioactivity in Soil (Ingrowth) | | | |
|--|---------------|-----------------|----------------------|
| Lab #: | 244072 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 6PBIF002-001 | Sampled: | 02/19/07 07:30 |
| Type: | IDUP | Received: | 03/25/11 |
| MSS Lab ID: | 244072-001 | Prepared: | 02/19/07 07:30 |
| Lab ID: | QC683533 | Analyzed: | 04/08/13 20:12 |
| Matrix: | Soil | Duration (sec): | 2,700 |
| Units: | pCi/g | Sample Amount: | 294 g |
| Basis: | dry | Uncert. Sigma: | 2 |
| Diln Fac: | 1.00 | Uncert. Units: | pCi/g |
| Batch#: | 196775 | | |

| Analyte | MSS Result | MSS TPU | Result | TPU | MDA | Project MDA | RPD | Lim | RER | Lim |
|-------------------------------|------------|---------|-------------|--------|--------|-------------|------|-----|-------|-----|
| Americium-241 | -0.0146 U | 0.168 | -0.0147 U | 0.192 | 0.158 | 0.9 | NC | 40 | NC | 1 |
| Bismuth-212 | 0.828 | 0.430 | 0.521 | 0.430 | 0.260 | | 45.6 | 40 | 0.358 | 1 |
| Bismuth-214 | 0.545 | 0.0995 | 0.414 | 0.0909 | 0.0419 | | 27.4 | 40 | 0.690 | 1 |
| Cesium-137 | 0.0270 | 0.0334 | 0 U | 0.0338 | 0.0329 | 0.07 | NC | 40 | NC | 1 |
| Cobalt-60 | 0 U | 0.0155 | 0.00794 U b | 0.0233 | 0.0414 | 0.03 | NC | 40 | NC | 1 |
| Europium-152 | 0.0279 U | 0.0809 | 0.0548 U | 0.0818 | 0.0766 | 0.1 | NC | 40 | NC | 1 |
| Europium-154 | 0.0399 U | 0.0946 | 0.0236 U b | 0.0503 | 0.297 | 0.2 | NC | 40 | NC | 1 |
| Lead-212 | 0.473 | 0.0835 | 0.447 | 0.0826 | 0.0360 | | 5.76 | 40 | 0.160 | 1 |
| Lead-214 | 0.509 | 0.0973 | 0.546 | 0.0883 | 0.0402 | | 6.95 | 40 | 0.197 | 1 |
| Potassium-40 | 8.28 | 1.07 | 7.90 | 1.05 | 0.307 | | 4.68 | 40 | 0.178 | 1 |
| Protactinium-234 | -0.0146 U | 0.0496 | 0.0276 U | 0.0392 | 0.0961 | | NC | 40 | NC | 1 |
| Radium-226 (By Bismuth-214) | 0.545 | 0.0995 | 0.414 | 0.0909 | 0.0419 | 0.2 | 27.4 | 40 | 0.690 | 1 |
| Thallium-208 | 0.184 | 0.0516 | 0.167 | 0.0402 | 0.0130 | | 9.71 | 40 | 0.186 | 1 |
| Thorium-232 (By Actinium-228) | 0.550 | 0.124 | 0.333 | 0.101 | 0.0740 | 0.9 | 49.1 | 40 | 0.962 | 1 |
| Thorium-234 | 0.886 U | 0.461 | 0.561 U | 0.555 | 1.21 | | NC | 40 | NC | 1 |
| Uranium-235 | 0.0679 U | 0.0310 | 0.0509 U | 0.0397 | 0.145 | 0.18 | NC | 40 | NC | 1 |

U= Not Detected

b= See narrative

NC= Not Calculated

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

RER= Relative Error Ratio

RPD= Relative Percent Difference

TPU= Total Propagated Uncertainty

STRONTIUM-90 ANALYSIS REPORT

Count Date: 2/27/2007
 Batch ID: NWTLAB022707-014
 Performed By: P Smith

Instrument ID: Protean WPC 9550
 Detector ID: 0615608
 Cal Due Date: 9/27/2007

Count Time: 30 min
⁹⁰Y Eff.: 31.1%
⁹⁰Sr Eff.: 26.9%
⁹⁰Sr Added: 10 mg

| Sample ID | Collected m/dd/yy hh:mm | ⁹⁰ Y in-growth m/dd/yy hh:mm | Counted m/dd/yy hh:mm | Aliquot Mass grams | Initial Mass grams | Final Mass grams | ⁹⁰ Sr Yield percent | Total CPM | Total Counts | ⁹⁰ Sr Activity pCi/g | MDC pCi/g | 2 σ Uncert. pCi/g |
|-------------------|----------------------------|--|--------------------------|-----------------------|-----------------------|---------------------|-----------------------------------|--------------|-----------------|------------------------------------|--------------|----------------------|
| 6PBIF002-006 | 2/19/07 8:20 | 2/27/07 11:14 | 2/27/07 23:27 | 10 | 9.4044 | 9.4159 | 103.0% | 0.533 | 16 | -0.003 | 0.068 | 0.034 |
| 6PBIF002-016 | 2/19/07 10:00 | 2/27/07 11:14 | 2/27/07 23:57 | 10 | 9.4294 | 9.4404 | 98.0% | 0.733 | 22 | 0.016 | 0.072 | 0.080 |
| Method Spike 3.49 | 2/26/07 7:00 | 2/27/07 11:14 | 2/28/07 6:02 | 10 | 9.4284 | 9.4392 | 96.0% | 22.067 | 662 | 3.532 | 0.121 | 1.524 |
| Blank | 2/26/07 7:00 | 2/27/07 11:15 | 2/28/07 6:33 | 10 | 9.3939 | 9.3951 | | 0.567 | 17 | | | |

JERICO BACKFILL

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Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-001 | Received: | 05/13/11 |
| Lab ID: | 244071-001 | Prepared: | 05/13/11 10:00 |
| Matrix: | Soil | Analyzed: | 01/08/13 16:32 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 325 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:00 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.00142 U | 0.122 | 0.101 | 0.9 |
| Bismuth-212 | 0.233 U | 0.355 | 0.267 | |
| Bismuth-214 | 0.289 | 0.0716 | 0.0273 | |
| Cesium-137 | 0.000394 U | 0.0249 | 0.0204 | 0.07 |
| Cobalt-60 | -0.00233 U | 0.0273 | 0.0221 | 0.03 |
| Europium-152 | 0.0660 | 0.0879 | 0.0496 | 0.1 |
| Europium-154 | 0.0110 U | 0.0195 | 0.171 | 0.2 |
| Lead-212 | 0.261 | 0.0653 | 0.0355 | |
| Lead-214 | 0.328 | 0.0704 | 0.0395 | |
| Potassium-40 | 9.83 | 0.990 | 0.246 | |
| Protactinium-234 | 0.0483 U | 0.0607 | 0.0814 | |
| Radium-226 (By Bismuth-214) | 0.289 | 0.0716 | 0.0273 | 0.2 |
| Thallium-208 | 0.123 | 0.0337 | 0.0123 | |
| Thorium-232 (By Actinium-228) | 0.274 | 0.104 | 0.0720 | 0.9 |
| Thorium-234 | 0.457 U | 1.13 | 0.907 | |
| Uranium-235 | 0.0435 U | 0.0364 | 0.124 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-002 | Received: | 05/25/11 |
| Lab ID: | 244071-002 | Prepared: | 05/13/11 10:05 |
| Matrix: | Soil | Analyzed: | 01/08/13 16:34 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 315 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:05 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.0153 U | 0.155 | 0.127 | 0.9 |
| Bismuth-212 | 0.810 | 0.332 | 0.115 | |
| Bismuth-214 | 0.276 | 0.0816 | 0.0380 | |
| Cesium-137 | 0.0143 U | 0.0250 | 0.0189 | 0.07 |
| Cobalt-60 | -0.00325 U | 0.0308 | 0.0248 | 0.03 |
| Europium-152 | 0.0391 U | 0.0840 | 0.0610 | 0.1 |
| Europium-154 | 0.0218 U | 0.0259 | 0.195 | 0.2 |
| Lead-212 | 0.281 | 0.0626 | 0.0326 | |
| Lead-214 | 0.303 | 0.0780 | 0.0429 | |
| Potassium-40 | 10.2 | 1.04 | 0.283 | |
| Protactinium-234 | 0.0496 U | 0.101 | 0.0803 | |
| Radium-226 (By Bismuth-214) | 0.276 | 0.0816 | 0.0380 | 0.2 |
| Thallium-208 | 0.100 | 0.0378 | 0.0197 | |
| Thorium-232 (By Actinium-228) | 0.528 | 0.132 | 0.0502 | 0.9 |
| Thorium-234 | 0.134 U | 0.207 | 1.24 | |
| Uranium-235 | 0.166 | 0.137 | 0.117 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-003 | Received: | 05/25/11 |
| Lab ID: | 244071-003 | Prepared: | 05/13/11 10:10 |
| Matrix: | Soil | Analyzed: | 01/09/13 08:32 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 328 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:10 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|---------|--------|-------------|
| Americium-241 | -0.00269 U | 0.120 | 0.0986 | 0.9 |
| Bismuth-212 | 0.356 | 0.346 | 0.212 | |
| Bismuth-214 | 0.313 | 0.0754 | 0.0290 | |
| Cesium-137 | 0.00530 U | 0.0242 | 0.0193 | 0.07 |
| Cobalt-60 | 0 U | 0.00575 | 0.0259 | 0.03 |
| Europium-152 | 0.0432 | 0.0871 | 0.0422 | 0.1 |
| Europium-154 | 0.0751 U | 0.160 | 0.119 | 0.2 |
| Lead-212 | 0.271 | 0.0702 | 0.0388 | |
| Lead-214 | 0.301 | 0.0629 | 0.0368 | |
| Potassium-40 | 9.09 | 0.980 | 0.281 | |
| Protactinium-234 | -0.00319 U | 0.00807 | 0.0878 | |
| Radium-226 (By Bismuth-214) | 0.313 | 0.0754 | 0.0290 | 0.2 |
| Thallium-208 | 0.0823 | 0.0290 | 0.0154 | |
| Thorium-232 (By Actinium-228) | 0.282 | 0.0958 | 0.0653 | 0.9 |
| Thorium-234 | 1.22 | 1.16 | 0.829 | |
| Uranium-235 | 0.0362 U | 0.0334 | 0.118 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-004 | Received: | 05/25/11 |
| Lab ID: | 244071-004 | Prepared: | 05/13/11 10:15 |
| Matrix: | Soil | Analyzed: | 01/09/13 08:34 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 315 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:15 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0702 U | 0.136 | 0.107 | 0.9 |
| Bismuth-212 | 0.425 | 0.450 | 0.269 | |
| Bismuth-214 | 0.278 | 0.0780 | 0.0372 | |
| Cesium-137 | 0.00596 U | 0.0226 | 0.0179 | 0.07 |
| Cobalt-60 | 0.00155 U | 0.0214 | 0.0291 | 0.03 |
| Europium-152 | 0.0338 U | 0.0643 | 0.0420 | 0.1 |
| Europium-154 | 0.00542 U | 0.0173 | 0.158 | 0.2 |
| Lead-212 | 0.273 | 0.0671 | 0.0430 | |
| Lead-214 | 0.405 | 0.0943 | 0.0481 | |
| Potassium-40 | 9.10 | 1.01 | 0.303 | |
| Protactinium-234 | 0.0132 U | 0.0220 | 0.0883 | |
| Radium-226 (By Bismuth-214) | 0.278 | 0.0780 | 0.0372 | 0.2 |
| Thallium-208 | 0.0886 | 0.0309 | 0.0160 | |
| Thorium-232 (By Actinium-228) | 0.442 | 0.124 | 0.0369 | 0.9 |
| Thorium-234 | 0.465 U | 0.597 | 0.978 | |
| Uranium-235 | 0.137 | 0.147 | 0.128 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-005 | Received: | 05/25/11 |
| Lab ID: | 244071-005 | Prepared: | 05/13/11 10:20 |
| Matrix: | Soil | Analyzed: | 01/09/13 09:25 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 322 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:20 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0 U | 0.0899 | 0.107 | 0.9 |
| Bismuth-212 | 0.184 U | 0.358 | 0.275 | |
| Bismuth-214 | 0.383 | 0.0916 | 0.0339 | |
| Cesium-137 | 0.0133 U | 0.0222 | 0.0165 | 0.07 |
| Cobalt-60 | -0.00817 U | 0.0289 | 0.0224 | 0.03 |
| Europium-152 | 0.0547 | 0.0473 | 0.0466 | 0.1 |
| Europium-154 | -0.0525 U | 0.240 | 0.192 | 0.2 |
| Lead-212 | 0.302 | 0.0622 | 0.0328 | |
| Lead-214 | 0.354 | 0.0774 | 0.0341 | |
| Potassium-40 | 10.6 | 1.09 | 0.313 | |
| Protactinium-234 | -0.00235 U | 0.0915 | 0.0752 | |
| Radium-226 (By Bismuth-214) | 0.383 | 0.0916 | 0.0339 | 0.2 |
| Thallium-208 | 0.115 | 0.0386 | 0.0189 | |
| Thorium-232 (By Actinium-228) | 0.422 | 0.0964 | 0.0406 | 0.9 |
| Thorium-234 | 0.429 U | 0.599 | 0.936 | |
| Uranium-235 | 0.103 U | 0.131 | 0.105 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-006 | Received: | 05/25/11 |
| Lab ID: | 244071-006 | Prepared: | 05/13/11 10:25 |
| Matrix: | Soil | Analyzed: | 01/09/13 09:27 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 320 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:25 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0401 U | 0.138 | 0.111 | 0.9 |
| Bismuth-212 | 0.108 U | 0.283 | 0.284 | |
| Bismuth-214 | 0.335 | 0.0784 | 0.0334 | |
| Cesium-137 | 0.0138 U | 0.0252 | 0.0191 | 0.07 |
| Cobalt-60 | 0.0119 U | 0.0177 | 0.0246 | 0.03 |
| Europium-152 | 0.0111 U | 0.0337 | 0.0495 | 0.1 |
| Europium-154 | 0.0471 U | 0.128 | 0.161 | 0.2 |
| Lead-212 | 0.361 | 0.0650 | 0.0329 | |
| Lead-214 | 0.356 | 0.0777 | 0.0406 | |
| Potassium-40 | 9.03 | 0.950 | 0.254 | |
| Protactinium-234 | -0.0151 U | 0.0387 | 0.0833 | |
| Radium-226 (By Bismuth-214) | 0.335 | 0.0784 | 0.0334 | 0.2 |
| Thallium-208 | 0.121 | 0.0447 | 0.0220 | |
| Thorium-232 (By Actinium-228) | 0.395 | 0.0993 | 0.0474 | 0.9 |
| Thorium-234 | 0.320 U | 0.383 | 1.07 | |
| Uranium-235 | 0.0302 U | 0.0261 | 0.146 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-007 | Received: | 05/25/11 |
| Lab ID: | 244071-007 | Prepared: | 05/13/11 10:30 |
| Matrix: | Soil | Analyzed: | 01/09/13 10:26 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 311 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0341 U | 0.155 | 0.126 | 0.9 |
| Bismuth-212 | 0.288 | 0.360 | 0.270 | |
| Bismuth-214 | 0.344 | 0.0998 | 0.0445 | |
| Cesium-137 | 0.00260 U | 0.0266 | 0.0216 | 0.07 |
| Cobalt-60 | -0.0117 U | 0.0364 | 0.0283 | 0.03 |
| Europium-152 | 0.0480 U | 0.0518 | 0.0560 | 0.1 |
| Europium-154 | 0.0805 U | 0.228 | 0.178 | 0.2 |
| Lead-212 | 0.325 | 0.0698 | 0.0374 | |
| Lead-214 | 0.323 | 0.0841 | 0.0431 | |
| Potassium-40 | 10.0 | 1.05 | 0.281 | |
| Protactinium-234 | 0.0293 U | 0.0963 | 0.0820 | |
| Radium-226 (By Bismuth-214) | 0.344 | 0.0998 | 0.0445 | 0.2 |
| Thallium-208 | 0.133 | 0.0408 | 0.0185 | |
| Thorium-232 (By Actinium-228) | 0.329 | 0.121 | 0.0691 | 0.9 |
| Thorium-234 | 0.267 U | 0.395 | 1.04 | |
| Uranium-235 | 0.0599 U | 0.0422 | 0.132 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-008 | Received: | 05/25/11 |
| Lab ID: | 244071-008 | Prepared: | 05/13/11 10:35 |
| Matrix: | Soil | Analyzed: | 01/09/13 10:30 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 321 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:35 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | 0.0413 U | 0.154 | 0.124 | 0.9 |
| Bismuth-212 | 0.355 | 0.368 | 0.227 | |
| Bismuth-214 | 0.363 | 0.0794 | 0.0305 | |
| Cesium-137 | -0.00654 U | 0.0248 | 0.0197 | 0.07 |
| Cobalt-60 | -0.000477 U | 0.0216 | 0.0177 | 0.03 |
| Europium-152 | 0.0524 | 0.0625 | 0.0456 | 0.1 |
| Europium-154 | 0.0227 U | 0.0283 | 0.123 | 0.2 |
| Lead-212 | 0.266 | 0.0654 | 0.0369 | |
| Lead-214 | 0.347 | 0.0775 | 0.0437 | |
| Potassium-40 | 10.8 | 1.05 | 0.274 | |
| Protactinium-234 | 0.0174 U | 0.0372 | 0.0921 | |
| Radium-226 (By Bismuth-214) | 0.363 | 0.0794 | 0.0305 | 0.2 |
| Thallium-208 | 0.0912 | 0.0362 | 0.0190 | |
| Thorium-232 (By Actinium-228) | 0.416 | 0.0968 | 0.0304 | 0.9 |
| Thorium-234 | 0.692 U | 1.13 | 0.889 | |
| Uranium-235 | 0.124 | 0.147 | 0.118 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-009 | Received: | 05/25/11 |
| Lab ID: | 244071-009 | Prepared: | 05/13/11 10:40 |
| Matrix: | Soil | Analyzed: | 01/09/13 12:04 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 308 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:40 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0182 U | 0.128 | 0.104 | 0.9 |
| Bismuth-212 | 0.283 U | 0.394 | 0.303 | |
| Bismuth-214 | 0.413 | 0.0895 | 0.0322 | |
| Cesium-137 | 0.00324 U | 0.0244 | 0.0197 | 0.07 |
| Cobalt-60 | 0.00903 U | 0.0246 | 0.0226 | 0.03 |
| Europium-152 | 0.0250 U | 0.0893 | 0.0544 | 0.1 |
| Europium-154 | 0.0365 U | 0.123 | 0.157 | 0.2 |
| Lead-212 | 0.255 | 0.0642 | 0.0367 | |
| Lead-214 | 0.320 | 0.0815 | 0.0409 | |
| Potassium-40 | 10.3 | 1.06 | 0.284 | |
| Protactinium-234 | 0.0545 U | 0.101 | 0.0825 | |
| Radium-226 (By Bismuth-214) | 0.413 | 0.0895 | 0.0322 | 0.2 |
| Thallium-208 | 0.0882 | 0.0323 | 0.0180 | |
| Thorium-232 (By Actinium-228) | 0.437 | 0.107 | 0.0165 | 0.9 |
| Thorium-234 | 0.578 U | 0.602 | 0.953 | |
| Uranium-235 | 0.117 | 0.150 | 0.116 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-010 | Received: | 05/25/11 |
| Lab ID: | 244071-010 | Prepared: | 05/13/11 10:45 |
| Matrix: | Soil | Analyzed: | 01/09/13 12:06 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 316 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:45 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|--------|--------|-------------|
| Americium-241 | -0.0410 U | 0.166 | 0.134 | 0.9 |
| Bismuth-212 | 0.197 U | 0.300 | 0.221 | |
| Bismuth-214 | 0.372 | 0.0889 | 0.0379 | |
| Cesium-137 | -0.00299 U | 0.0219 | 0.0177 | 0.07 |
| Cobalt-60 | 0.00187 U b | 0.0169 | 0.0359 | 0.03 |
| Europium-152 | 0.0170 U | 0.0184 | 0.0564 | 0.1 |
| Europium-154 | 0.0119 U | 0.0513 | 0.166 | 0.2 |
| Lead-212 | 0.289 | 0.0623 | 0.0352 | |
| Lead-214 | 0.368 | 0.0800 | 0.0468 | |
| Potassium-40 | 9.25 | 0.998 | 0.294 | |
| Protactinium-234 | -0.0454 U | 0.118 | 0.0953 | |
| Radium-226 (By Bismuth-214) | 0.372 | 0.0889 | 0.0379 | 0.2 |
| Thallium-208 | 0.0936 | 0.0340 | 0.0170 | |
| Thorium-232 (By Actinium-228) | 0.272 | 0.110 | 0.0567 | 0.9 |
| Thorium-234 | 1.68 | 1.19 | 0.873 | |
| Uranium-235 | 0.0453 U | 0.0386 | 0.116 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-011 | Received: | 05/25/11 |
| Lab ID: | 244071-011 | Prepared: | 05/13/11 10:50 |
| Matrix: | Soil | Analyzed: | 01/09/13 12:52 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 306 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:50 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|--------|-------------|
| Americium-241 | -0.00148 U | 0.140 | 0.115 | 0.9 |
| Bismuth-212 | 0.483 | 0.409 | 0.260 | |
| Bismuth-214 | 0.387 | 0.0870 | 0.0331 | |
| Cesium-137 | 0.00121 U | 0.0282 | 0.0231 | 0.07 |
| Cobalt-60 | -0.00820 U b | 0.0397 | 0.0316 | 0.03 |
| Europium-152 | 0.0498 U | 0.102 | 0.0534 | 0.1 |
| Europium-154 | -0.00157 U | 0.00894 | 0.198 | 0.2 |
| Lead-212 | 0.313 | 0.0749 | 0.0416 | |
| Lead-214 | 0.339 | 0.0719 | 0.0412 | |
| Potassium-40 | 10.0 | 1.08 | 0.319 | |
| Protactinium-234 | 0.0346 U | 0.0775 | 0.0905 | |
| Radium-226 (By Bismuth-214) | 0.387 | 0.0870 | 0.0331 | 0.2 |
| Thallium-208 | 0.131 | 0.0420 | 0.0189 | |
| Thorium-232 (By Actinium-228) | 0.496 | 0.127 | 0.0499 | 0.9 |
| Thorium-234 | 0.460 U | 0.721 | 1.03 | |
| Uranium-235 | 0.0521 U | 0.0415 | 0.132 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-012 | Received: | 05/25/11 |
| Lab ID: | 244071-012 | Prepared: | 05/13/11 10:55 |
| Matrix: | Soil | Analyzed: | 01/09/13 13:39 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 304 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 10:55 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0444 U | 0.151 | 0.122 | 0.9 |
| Bismuth-212 | -0.0356 U | 0.0903 | 0.279 | |
| Bismuth-214 | 0.376 | 0.0796 | 0.0281 | |
| Cesium-137 | 0.0179 U | 0.0261 | 0.0194 | 0.07 |
| Cobalt-60 | 0.00859 U | 0.0305 | 0.0237 | 0.03 |
| Europium-152 | 0.00921 U | 0.0522 | 0.0695 | 0.1 |
| Europium-154 | 0.0606 U | 0.173 | 0.173 | 0.2 |
| Lead-212 | 0.324 | 0.0728 | 0.0382 | |
| Lead-214 | 0.411 | 0.0915 | 0.0417 | |
| Potassium-40 | 9.77 | 1.03 | 0.288 | |
| Protactinium-234 | 0.0359 U | 0.0663 | 0.0857 | |
| Radium-226 (By Bismuth-214) | 0.376 | 0.0796 | 0.0281 | 0.2 |
| Thallium-208 | 0.0792 | 0.0343 | 0.0189 | |
| Thorium-232 (By Actinium-228) | 0.212 | 0.100 | 0.0580 | 0.9 |
| Thorium-234 | 0.281 U | 0.337 | 1.06 | |
| Uranium-235 | 0.0712 U | 0.0400 | 0.112 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-013 | Received: | 05/25/11 |
| Lab ID: | 244071-013 | Prepared: | 05/13/11 11:00 |
| Matrix: | Soil | Analyzed: | 01/09/13 13:39 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 317 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:00 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|--------|--------|-------------|
| Americium-241 | 0.0723 U | 0.129 | 0.102 | 0.9 |
| Bismuth-212 | 0.234 U | 0.368 | 0.239 | |
| Bismuth-214 | 0.408 | 0.0798 | 0.0242 | |
| Cesium-137 | 0.00825 U | 0.0209 | 0.0160 | 0.07 |
| Cobalt-60 | -0.00255 U b | 0.0140 | 0.0325 | 0.03 |
| Europium-152 | 0.0141 U | 0.0485 | 0.0585 | 0.1 |
| Europium-154 | 0.0100 U b | 0.0370 | 0.214 | 0.2 |
| Lead-212 | 0.274 | 0.0690 | 0.0384 | |
| Lead-214 | 0.391 | 0.0866 | 0.0448 | |
| Potassium-40 | 9.30 | 1.00 | 0.277 | |
| Protactinium-234 | -0.0296 U | 0.0960 | 0.0773 | |
| Radium-226 (By Bismuth-214) | 0.408 | 0.0798 | 0.0242 | 0.2 |
| Thallium-208 | 0.136 | 0.0437 | 0.0198 | |
| Thorium-232 (By Actinium-228) | 0.417 | 0.0908 | 0.0440 | 0.9 |
| Thorium-234 | 0.702 U | 0.585 | 0.943 | |
| Uranium-235 | 0.0417 U | 0.0318 | 0.122 | 0.18 |

U= Not Detected

b= See narrative

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-014 | Received: | 05/25/11 |
| Lab ID: | 244071-014 | Prepared: | 05/13/11 11:05 |
| Matrix: | Soil | Analyzed: | 01/09/13 14:30 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 318 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:05 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|---------|-------------|
| Americium-241 | -0.0290 U | 0.133 | 0.108 | 0.9 |
| Bismuth-212 | 0.258 U | 0.359 | 0.267 | |
| Bismuth-214 | 0.253 | 0.0837 | 0.0416 | |
| Cesium-137 | 0.0103 U | 0.0258 | 0.0201 | 0.07 |
| Cobalt-60 | 0.00316 U | 0.0318 | 0.0257 | 0.03 |
| Europium-152 | 0.0314 U | 0.0644 | 0.0557 | 0.1 |
| Europium-154 | 0.0281 U | 0.0550 | 0.182 | 0.2 |
| Lead-212 | 0.275 | 0.0597 | 0.0322 | |
| Lead-214 | 0.363 | 0.0770 | 0.0414 | |
| Potassium-40 | 9.38 | 0.998 | 0.273 | |
| Protactinium-234 | -0.00925 U | 0.0188 | 0.0892 | |
| Radium-226 (By Bismuth-214) | 0.253 | 0.0837 | 0.0416 | 0.2 |
| Thallium-208 | 0.113 | 0.0296 | 0.00907 | |
| Thorium-232 (By Actinium-228) | 0.289 | 0.0907 | 0.0644 | 0.9 |
| Thorium-234 | 1.16 | 1.12 | 0.852 | |
| Uranium-235 | 0.0426 U | 0.0281 | 0.139 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-015 | Received: | 05/25/11 |
| Lab ID: | 244071-015 | Prepared: | 05/13/11 11:10 |
| Matrix: | Soil | Analyzed: | 01/09/13 14:31 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 304 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:10 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | 0.0920 U | 0.138 | 0.107 | 0.9 |
| Bismuth-212 | 0.243 | 0.347 | 0.217 | |
| Bismuth-214 | 0.366 | 0.0830 | 0.0320 | |
| Cesium-137 | 0.00126 U | 0.0246 | 0.0201 | 0.07 |
| Cobalt-60 | -0.00231 U | 0.0217 | 0.0174 | 0.03 |
| Europium-152 | -0.00334 U | 0.0706 | 0.0579 | 0.1 |
| Europium-154 | 0.0932 U | 0.165 | 0.164 | 0.2 |
| Lead-212 | 0.303 | 0.0664 | 0.0362 | |
| Lead-214 | 0.320 | 0.0915 | 0.0488 | |
| Potassium-40 | 9.40 | 1.03 | 0.310 | |
| Protactinium-234 | 0.0560 U | 0.0958 | 0.0753 | |
| Radium-226 (By Bismuth-214) | 0.366 | 0.0830 | 0.0320 | 0.2 |
| Thallium-208 | 0.109 | 0.0387 | 0.0192 | |
| Thorium-232 (By Actinium-228) | 0.224 | 0.101 | 0.0831 | 0.9 |
| Thorium-234 | 0.797 U | 0.584 | 0.878 | |
| Uranium-235 | 0.0404 U | 0.0297 | 0.129 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-016 | Received: | 05/25/11 |
| Lab ID: | 244071-016 | Prepared: | 05/13/11 11:15 |
| Matrix: | Soil | Analyzed: | 01/09/13 15:38 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 317 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:15 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|---------|--------|-------------|
| Americium-241 | 0.00561 U | 0.129 | 0.106 | 0.9 |
| Bismuth-212 | 0.122 U | 0.335 | 0.282 | |
| Bismuth-214 | 0.330 | 0.0809 | 0.0342 | |
| Cesium-137 | 0.00230 U | 0.0199 | 0.0161 | 0.07 |
| Cobalt-60 | -0.00119 U | 0.0303 | 0.0247 | 0.03 |
| Europium-152 | 0.00953 U | 0.0664 | 0.0482 | 0.1 |
| Europium-154 | 0.00271 U | 0.00923 | 0.173 | 0.2 |
| Lead-212 | 0.310 | 0.0699 | 0.0372 | |
| Lead-214 | 0.341 | 0.0682 | 0.0413 | |
| Potassium-40 | 10.0 | 1.03 | 0.274 | |
| Protactinium-234 | 0.00766 U | 0.0724 | 0.0590 | |
| Radium-226 (By Bismuth-214) | 0.330 | 0.0809 | 0.0342 | 0.2 |
| Thallium-208 | 0.135 | 0.0359 | 0.0133 | |
| Thorium-232 (By Actinium-228) | 0.423 | 0.127 | 0.0568 | 0.9 |
| Thorium-234 | 1.39 | 1.12 | 0.839 | |
| Uranium-235 | 0.0625 U | 0.0443 | 0.130 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-017 | Received: | 05/25/11 |
| Lab ID: | 244071-017 | Prepared: | 05/13/11 11:20 |
| Matrix: | Soil | Analyzed: | 01/09/13 15:40 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 302 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:20 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|--------|--------|-------------|
| Americium-241 | -0.00203 U | 0.154 | 0.127 | 0.9 |
| Bismuth-212 | 0.441 | 0.408 | 0.290 | |
| Bismuth-214 | 0.410 | 0.0912 | 0.0364 | |
| Cesium-137 | 0.00808 U | 0.0236 | 0.0183 | 0.07 |
| Cobalt-60 | -0.00171 U | 0.0360 | 0.0294 | 0.03 |
| Europium-152 | 0.0405 U | 0.0642 | 0.0511 | 0.1 |
| Europium-154 | 0.0279 U | 0.0347 | 0.176 | 0.2 |
| Lead-212 | 0.297 | 0.0622 | 0.0319 | |
| Lead-214 | 0.422 | 0.0913 | 0.0464 | |
| Potassium-40 | 9.21 | 1.04 | 0.316 | |
| Protactinium-234 | 0.0260 U | 0.0360 | 0.0919 | |
| Radium-226 (By Bismuth-214) | 0.410 | 0.0912 | 0.0364 | 0.2 |
| Thallium-208 | 0.146 | 0.0384 | 0.0158 | |
| Thorium-232 (By Actinium-228) | 0.398 | 0.122 | 0.0432 | 0.9 |
| Thorium-234 | 0.458 U | 0.360 | 1.07 | |
| Uranium-235 | 0.0345 U | 0.0449 | 0.110 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-018 | Received: | 05/25/11 |
| Lab ID: | 244071-018 | Prepared: | 05/13/11 11:25 |
| Matrix: | Soil | Analyzed: | 01/09/13 16:25 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 320 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:25 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | -0.0682 U | 0.168 | 0.135 | 0.9 |
| Bismuth-212 | 0.0665 U | 0.332 | 0.266 | |
| Bismuth-214 | 0.346 | 0.0854 | 0.0356 | |
| Cesium-137 | 0.00468 U | 0.0274 | 0.0221 | 0.07 |
| Cobalt-60 | 0.0114 U | 0.0323 | 0.0248 | 0.03 |
| Europium-152 | 0.0106 U | 0.0198 | 0.0585 | 0.1 |
| Europium-154 | 0.0708 U | 0.162 | 0.152 | 0.2 |
| Lead-212 | 0.327 | 0.0654 | 0.0346 | |
| Lead-214 | 0.417 | 0.0754 | 0.0390 | |
| Potassium-40 | 9.50 | 1.02 | 0.291 | |
| Protactinium-234 | 0.0363 U | 0.0838 | 0.0886 | |
| Radium-226 (By Bismuth-214) | 0.346 | 0.0854 | 0.0356 | 0.2 |
| Thallium-208 | 0.115 | 0.0379 | 0.0185 | |
| Thorium-232 (By Actinium-228) | 0.278 | 0.0938 | 0.0798 | 0.9 |
| Thorium-234 | 0.323 U | 0.978 | 0.784 | |
| Uranium-235 | 0.0559 U | 0.0375 | 0.133 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-019 | Received: | 05/25/11 |
| Lab ID: | 244071-019 | Prepared: | 05/13/11 11:30 |
| Matrix: | Soil | Analyzed: | 01/09/13 16:35 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 313 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|----------|--------|-------------|
| Americium-241 | 0.131 | 0.127 | 0.0942 | 0.9 |
| Bismuth-212 | 0.358 | 0.416 | 0.268 | |
| Bismuth-214 | 0.346 | 0.0869 | 0.0357 | |
| Cesium-137 | 0.00404 U | 0.0256 | 0.0206 | 0.07 |
| Cobalt-60 | 0.0107 U | 0.0318 | 0.0245 | 0.03 |
| Europium-152 | 0.0264 U | 0.0834 | 0.0487 | 0.1 |
| Europium-154 | 0.0181 U | 0.0577 | 0.141 | 0.2 |
| Lead-212 | 0.319 | 0.0606 | 0.0305 | |
| Lead-214 | 0.363 | 0.0879 | 0.0458 | |
| Potassium-40 | 10.5 | 1.08 | 0.318 | |
| Protactinium-234 | 0.000259 U | 0.000685 | 0.0922 | |
| Radium-226 (By Bismuth-214) | 0.346 | 0.0869 | 0.0357 | 0.2 |
| Thallium-208 | 0.100 | 0.0302 | 0.0142 | |
| Thorium-232 (By Actinium-228) | 0.261 | 0.0969 | 0.0501 | 0.9 |
| Thorium-234 | 0.651 U | 0.621 | 0.943 | |
| Uranium-235 | 0.0142 U | 0.0395 | 0.0987 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-020 | Received: | 05/25/11 |
| Lab ID: | 244071-020 | Prepared: | 05/13/11 11:35 |
| Matrix: | Soil | Analyzed: | 01/10/13 07:59 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 308 g |
| Diln Fac: | 1.00 | Uncert. Sigma: | 2 |
| Batch#: | 196774 | Uncert. Units: | pCi/g |
| Sampled: | 05/13/11 11:35 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-----------|--------|--------|-------------|
| Americium-241 | 0.0245 U | 0.135 | 0.110 | 0.9 |
| Bismuth-212 | 0.306 | 0.336 | 0.253 | |
| Bismuth-214 | 0.342 | 0.0817 | 0.0345 | |
| Cesium-137 | 0.0114 U | 0.0299 | 0.0235 | 0.07 |
| Cobalt-60 | 0.00477 U | 0.0206 | 0.0258 | 0.03 |
| Europium-152 | 0.0373 U | 0.0517 | 0.0492 | 0.1 |
| Europium-154 | 0.0338 U | 0.0434 | 0.171 | 0.2 |
| Lead-212 | 0.265 | 0.0774 | 0.0431 | |
| Lead-214 | 0.352 | 0.0793 | 0.0384 | |
| Potassium-40 | 11.3 | 1.15 | 0.326 | |
| Protactinium-234 | 0.00556 U | 0.0663 | 0.0947 | |
| Radium-226 (By Bismuth-214) | 0.342 | 0.0817 | 0.0345 | 0.2 |
| Thallium-208 | 0.137 | 0.0408 | 0.0184 | |
| Thorium-232 (By Actinium-228) | 0.361 | 0.104 | 0.0479 | 0.9 |
| Thorium-234 | 0.208 U | 1.26 | 1.02 | |
| Uranium-235 | 0.0428 U | 0.0321 | 0.108 | 0.18 |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Batch QC Report

| Gamma Radioactivity in Soil (Ingrowth) | | | |
|--|---------------|-----------------|----------------------|
| Lab #: | 244071 | Location: | CTO4 |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440004.0004 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 04A-DIA-001 | Sampled: | 05/13/11 10:00 |
| Type: | IDUP | Received: | 05/13/11 |
| MSS Lab ID: | 244071-001 | Prepared: | 05/13/11 00:00 |
| Lab ID: | QC683532 | Analyzed: | 04/09/13 08:03 |
| Matrix: | Soil | Duration (sec): | 2,700 |
| Units: | pCi/g | Sample Amount: | 325 g |
| Basis: | dry | Uncert. Sigma: | 2 |
| Diln Fac: | 1.00 | Uncert. Units: | pCi/g |
| Batch#: | 196774 | | |

| Analyte | MSS Result | MSS TPU | Result | TPU | MDA | Project MDA | RPD | Lim | RER | Lim |
|-------------------------------|------------|---------|------------|--------|--------|-------------|------|-----|--------|-----|
| Americium-241 | 0.00142 U | 0.122 | 0.0505 U | 0.130 | 0.104 | 0.9 | NC | 40 | NC | 1 |
| Bismuth-212 | 0.233 U | 0.355 | 0.132 U | 0.271 | 0.284 | | NC | 40 | NC | 1 |
| Bismuth-214 | 0.289 | 0.0728 | 0.312 | 0.0793 | 0.0357 | | 7.63 | 40 | 0.151 | 1 |
| Cesium-137 | 0.000394 U | 0.0249 | 0.00800 U | 0.0261 | 0.0206 | 0.07 | NC | 40 | NC | 1 |
| Cobalt-60 | -0.00233 U | 0.0273 | 0.000130 U | 0.0270 | 0.0222 | 0.03 | NC | 40 | NC | 1 |
| Europium-152 | 0.0660 | 0.0880 | 0.0248 U | 0.0757 | 0.0579 | 0.1 | NC | 40 | NC | 1 |
| Europium-154 | 0.0110 U | 0.0195 | 0.0131 U | 0.0558 | 0.142 | 0.2 | NC | 40 | NC | 1 |
| Lead-212 | 0.261 | 0.0688 | 0.325 | 0.0662 | 0.0329 | | 21.8 | 40 | 0.473 | 1 |
| Lead-214 | 0.328 | 0.0728 | 0.336 | 0.0858 | 0.0401 | | 2.43 | 40 | 0.0508 | 1 |
| Potassium-40 | 9.83 | 1.11 | 10.3 | 1.15 | 0.149 | | 4.37 | 40 | 0.195 | 1 |
| Protactinium-234 | 0.0483 U | 0.0618 | 0.0335 U | 0.0820 | 0.0721 | | NC | 40 | NC | 1 |
| Radium-226 (By Bismuth-214) | 0.289 | 0.0728 | 0.312 | 0.0793 | 0.0357 | 0.2 | 7.63 | 40 | 0.151 | 1 |
| Thallium-208 | 0.123 | 0.0347 | 0.130 | 0.0341 | 0.0119 | | 5.63 | 40 | 0.103 | 1 |
| Thorium-232 (By Actinium-228) | 0.274 | 0.106 | 0.455 | 0.111 | 0.0402 | 0.9 | 49.6 | 40 | 0.835 | 1 |
| Thorium-234 | 0.457 U | 1.13 | 0.726 U | 0.572 | 0.922 | | NC | 40 | NC | 1 |
| Uranium-235 | 0.0435 U | 0.0365 | 0.0536 U | 0.0506 | 0.113 | 0.18 | NC | 40 | NC | 1 |

U= Not Detected

NC= Not Calculated

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

RER= Relative Error Ratio

RPD= Relative Percent Difference

TPU= Total Propagated Uncertainty

Tetra Tech EC, Inc.

Client Sample ID: 04A-DIA-002

Radiochemistry

Lab Sample ID: F2C230449-003

Work Order: MRK12

Matrix: SOLID

Date Collected: 05/13/11 1005

Date Received: 03/23/12 1105

| Parameter | Result | Qual | Total Uncert. (2 σ +/-) | RL | MDL | Count Time | Prep Date | Analysis Date |
|------------------|-------------|------|--------------------------------------|-------|-------|-----------------|--------------|------------------|
| Total SR BY GFPC | EPA-905 MOD | | | pCi/g | | Batch # 2083116 | | Yld % 86. |
| Strontium Total | -0.122 | U | 0.142 | 0.320 | 0.148 | 400 | 03/23/12 | 03/29/12 |

NOTE(S)

Data are incomplete without the case narrative.

Bold results are greater than the MDL.

U Result is less than the sample detection limit.

The MDL is an estimate of the measured concentration at which there is a 99% confidence that a given analyte is given sample matrix. This is functionally analogous to the "critical value" or the "limit of detection".

Ra-226 results analyzed by EPA 901.1 MOD were calculated and reported from the 46.09 percent abundant 609.31 KeV line of Bi-214.

F2C230449

ED_002781A_00003373-00099

Tetra Tech EC, Inc.

Client Sample ID: 04A-DIA-012

Radiochemistry

Lab Sample ID: F2C230449-004
Work Order: MRK13
Matrix: SOLID

Date Collected: 05/13/11 1055
Date Received: 03/23/12 1105

| Parameter | Result | Qual | Total Uncert. (2 σ +/-) | RL | MDL | Count Time | Prep Date | Analysis Date |
|------------------|-------------|------|--------------------------------------|-------|-------|-----------------|--------------|------------------|
| Total SR BY GFPC | EPA-905 MOD | | | pCi/g | | Batch # 2083116 | | Yld % 84. |
| Strontium Total | 0.156 | | 0.165 | 0.320 | 0.152 | 400 | 03/23/12 | 03/29/12 |

NOTE(S)

Data are incomplete without the case narrative.
Bold results are greater than the MDL.

The MDL is an estimate of the measured concentration at which there is a 99% confidence that a given analyte is given sample matrix. This is functionally analogous to the "critical value" or the "limit of detection".

Ra-226 results analyzed by EPA 901.1 MOD were calculated and reported from the 46.09 percent abundant 609.31 KeV line of Bi-214.

F2C230449

ED_002781A_00003373-00100

ATTACHMENT 2

REFERENCE AREA

SAMPLE RESULTS

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Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-001 | Received: | 12/20/13 |
| Lab ID: | 252048-001 | Prepared: | 12/26/13 07:34 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:03 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 342.98 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:25 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|----------|---------|-------------|
| Americium-241 | -0.08758 U | 0.2363 | 0.1915 | 0.9 |
| Bismuth-212 | 1.955 | 0.5740 | 0.2637 | |
| Bismuth-214 | 1.105 | 0.1287 | 0.04611 | |
| Cesium-137 | -0.01338 U | 0.03478 | 0.02765 | 0.07 |
| Cobalt-60 | 0.0007188 U | 0.03060 | 0.02512 | 0.03 |
| Europium-152 | 0.05040 U | 0.07584 | 0.06592 | |
| Europium-154 | 0.05718 U | 0.1181 | 0.1488 | |
| Lead-212 | 1.388 | 0.1212 | 0.05502 | |
| Lead-214 | 1.254 | 0.1363 | 0.05746 | |
| Potassium-40 | 10.05 | 1.013 | 0.2623 | |
| Protactinium-234 | 0.001922 U | 0.001842 | 0.1379 | |
| Radium-226 (By Bismuth-214) | 1.105 | 0.1287 | 0.04611 | 0.2 |
| Thallium-208 | 0.4524 | 0.06645 | 0.02853 | |
| Thorium-232 (By Actinium-228) | 1.538 | 0.2022 | 0.07577 | 0.9 |
| Thorium-234 | 0.7794 U | 0.9629 | 1.603 | |
| Uranium-235 | 0.1079 U | 0.05003 | 0.1929 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-002 | Received: | 12/20/13 |
| Lab ID: | 252048-002 | Prepared: | 12/26/13 07:39 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:05 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 324.61 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:27 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|---------|---------|-------------|
| Americium-241 | 0.008091 U | 0.2087 | 0.1716 | 0.9 |
| Bismuth-212 | 1.972 | 0.6309 | 0.2808 | |
| Bismuth-214 | 1.175 | 0.1466 | 0.05550 | |
| Cesium-137 | -0.01703 U | 0.03686 | 0.02903 | 0.07 |
| Cobalt-60 | 0.01409 U | 0.02346 | 0.01689 | 0.03 |
| Europium-152 | 0.07404 U | 0.05886 | 0.08023 | |
| Europium-154 | 0.04207 U | 0.08942 | 0.1627 | |
| Lead-212 | 1.385 | 0.1273 | 0.06006 | |
| Lead-214 | 1.374 | 0.1460 | 0.05710 | |
| Potassium-40 | 9.048 | 0.9568 | 0.2769 | |
| Protactinium-234 | -0.09764 U | 0.1687 | 0.1357 | |
| Radium-226 (By Bismuth-214) | 1.175 | 0.1466 | 0.05550 | 0.2 |
| Thallium-208 | 0.4791 | 0.07130 | 0.02972 | |
| Thorium-232 (By Actinium-228) | 1.922 | 0.2360 | 0.03901 | 0.9 |
| Thorium-234 | 0.7693 U | 1.896 | 1.534 | |
| Uranium-235 | 0.2335 | 0.1966 | 0.1488 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-003 | Received: | 12/20/13 |
| Lab ID: | 252048-003 | Prepared: | 12/26/13 07:44 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:09 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 326.9 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:29 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|---------|-------------|
| Americium-241 | -0.02106 U | 0.2608 | 0.2140 | 0.9 |
| Bismuth-212 | 1.960 | 0.6819 | 0.3384 | |
| Bismuth-214 | 1.062 | 0.1352 | 0.05239 | |
| Cesium-137 | 0.01642 | 0.02220 | 0.01613 | 0.07 |
| Cobalt-60 | -0.0006774 U | 0.03036 | 0.02492 | 0.03 |
| Europium-152 | 0.1011 | 0.05271 | 0.05713 | |
| Europium-154 | 0.1191 U | 0.2325 | 0.1792 | |
| Lead-212 | 1.342 | 0.1269 | 0.06089 | |
| Lead-214 | 1.220 | 0.1306 | 0.04985 | |
| Potassium-40 | 9.852 | 1.035 | 0.2677 | |
| Protactinium-234 | 0.01508 U | 0.01984 | 0.1411 | |
| Radium-226 (By Bismuth-214) | 1.062 | 0.1352 | 0.05239 | 0.2 |
| Thallium-208 | 0.4319 | 0.06686 | 0.02720 | |
| Thorium-232 (By Actinium-228) | 1.493 | 0.1984 | 0.04475 | 0.9 |
| Thorium-234 | 1.703 | 0.9548 | 1.438 | |
| Uranium-235 | 0.1183 U | 0.05073 | 0.2159 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-004 | Received: | 12/20/13 |
| Lab ID: | 252048-004 | Prepared: | 12/26/13 07:49 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:11 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 347.29 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:30 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | 0.1155 U | 0.2240 | 0.1797 | 0.9 |
| Bismuth-212 | 1.821 | 0.5484 | 0.3157 | |
| Bismuth-214 | 1.060 | 0.1331 | 0.05265 | |
| Cesium-137 | -0.01792 U | 0.03536 | 0.02780 | 0.07 |
| Cobalt-60 | -0.005019 U | 0.03048 | 0.02450 | 0.03 |
| Europium-152 | 0.04198 U | 0.04032 | 0.06834 | |
| Europium-154 | 0.03673 U | 0.07222 | 0.1262 | |
| Lead-212 | 1.362 | 0.1100 | 0.04673 | |
| Lead-214 | 1.217 | 0.1347 | 0.05590 | |
| Potassium-40 | 8.813 | 0.9104 | 0.2044 | |
| Protactinium-234 | -0.05470 U | 0.1530 | 0.1242 | |
| Radium-226 (By Bismuth-214) | 1.060 | 0.1331 | 0.05265 | 0.2 |
| Thallium-208 | 0.4290 | 0.06057 | 0.02459 | |
| Thorium-232 (By Actinium-228) | 1.497 | 0.1776 | 0.07352 | 0.9 |
| Thorium-234 | 1.368 U | 0.9646 | 1.560 | |
| Uranium-235 | 0.1284 U | 0.06110 | 0.2010 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-005 | Received: | 12/20/13 |
| Lab ID: | 252048-005 | Prepared: | 12/26/13 07:53 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:15 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 346.82 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:31 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|----------|---------|-------------|
| Americium-241 | -0.008130 U | 0.2624 | 0.2158 | 0.9 |
| Bismuth-212 | 1.955 | 0.6288 | 0.2751 | |
| Bismuth-214 | 0.9830 | 0.1282 | 0.04951 | |
| Cesium-137 | -0.001789 U | 0.02809 | 0.02298 | 0.07 |
| Cobalt-60 | -0.0007429 U | 0.03090 | 0.02537 | 0.03 |
| Europium-152 | 0.008361 U | 0.01641 | 0.06956 | |
| Europium-154 | 0.004159 U | 0.01993 | 0.1674 | |
| Lead-212 | 1.132 | 0.1105 | 0.05302 | |
| Lead-214 | 1.031 | 0.1228 | 0.04814 | |
| Potassium-40 | 9.130 | 0.9416 | 0.2107 | |
| Protactinium-234 | -0.002752 U | 0.005465 | 0.1139 | |
| Radium-226 (By Bismuth-214) | 0.9830 | 0.1282 | 0.04951 | 0.2 |
| Thallium-208 | 0.4119 | 0.05761 | 0.02030 | |
| Thorium-232 (By Actinium-228) | 1.378 | 0.2043 | 0.08456 | 0.9 |
| Thorium-234 | 1.095 U | 0.8416 | 1.789 | |
| Uranium-235 | 0.1278 U | 0.05499 | 0.2016 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-006 | Received: | 12/20/13 |
| Lab ID: | 252048-006 | Prepared: | 12/26/13 07:58 |
| Matrix: | Soil | Analyzed: | 01/16/14 08:55 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 318.97 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:32 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | 0.08348 U | 0.1936 | 0.1556 | 0.9 |
| Bismuth-212 | 0.6020 | 0.4200 | 0.2691 | |
| Bismuth-214 | 0.9238 | 0.1317 | 0.05352 | |
| Cesium-137 | 0.008367 U | 0.03125 | 0.02499 | 0.07 |
| Cobalt-60 | 0.0008991 U | 0.01761 | 0.01169 | 0.03 |
| Europium-152 | 0.01030 U | 0.06232 | 0.07440 | |
| Europium-154 | 0.06974 U | 0.2004 | 0.1567 | |
| Lead-212 | 1.026 | 0.1087 | 0.04989 | |
| Lead-214 | 1.128 | 0.1320 | 0.04947 | |
| Potassium-40 | 9.146 | 0.9541 | 0.2261 | |
| Protactinium-234 | -0.07595 U | 0.1566 | 0.1262 | |
| Radium-226 (By Bismuth-214) | 0.9238 | 0.1317 | 0.05352 | 0.2 |
| Thallium-208 | 0.3548 | 0.05600 | 0.02152 | |
| Thorium-232 (By Actinium-228) | 1.165 | 0.1501 | 0.07901 | 0.9 |
| Thorium-234 | 1.603 | 0.7324 | 1.061 | |
| Uranium-235 | 0.07596 U | 0.05625 | 0.1873 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-007 | Received: | 12/20/13 |
| Lab ID: | 252048-007 | Prepared: | 12/26/13 08:02 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:01 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 320.22 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:33 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|---------|-------------|
| Americium-241 | 0.00002118 U | 0.2144 | 0.1766 | 0.9 |
| Bismuth-212 | 1.429 | 0.7073 | 0.3667 | |
| Bismuth-214 | 0.9449 | 0.1253 | 0.04564 | |
| Cesium-137 | -0.003612 U | 0.02687 | 0.02175 | 0.07 |
| Cobalt-60 | 0.001492 U | 0.01195 | 0.02379 | 0.03 |
| Europium-152 | 0.09463 | 0.07250 | 0.06868 | |
| Europium-154 | 0.01063 U | 0.03353 | 0.1878 | |
| Lead-212 | 1.188 | 0.1142 | 0.05080 | |
| Lead-214 | 1.213 | 0.1420 | 0.05774 | |
| Potassium-40 | 8.450 | 0.9336 | 0.2802 | |
| Protactinium-234 | 0.01704 U | 0.03537 | 0.1216 | |
| Radium-226 (By Bismuth-214) | 0.9449 | 0.1253 | 0.04564 | 0.2 |
| Thallium-208 | 0.4005 | 0.06486 | 0.02731 | |
| Thorium-232 (By Actinium-228) | 1.352 | 0.2007 | 0.07262 | 0.9 |
| Thorium-234 | 1.021 U | 0.7369 | 1.446 | |
| Uranium-235 | 0.1544 U | 0.2206 | 0.1620 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-008 | Received: | 12/20/13 |
| Lab ID: | 252048-008 | Prepared: | 12/26/13 08:07 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:02 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 320.37 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:34 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | -0.04241 U | 0.2400 | 0.1958 | 0.9 |
| Bismuth-212 | 1.761 | 0.6403 | 0.3067 | |
| Bismuth-214 | 1.074 | 0.1418 | 0.05836 | |
| Cesium-137 | -0.009505 U | 0.03114 | 0.02478 | 0.07 |
| Cobalt-60 | 0.01058 U | 0.01993 | 0.01811 | 0.03 |
| Europium-152 | 0.03276 U | 0.05221 | 0.06434 | |
| Europium-154 | 0.02398 U | 0.03000 | 0.1588 | |
| Lead-212 | 1.108 | 0.1113 | 0.05201 | |
| Lead-214 | 1.140 | 0.1435 | 0.05906 | |
| Potassium-40 | 9.854 | 1.083 | 0.3125 | |
| Protactinium-234 | 0.04611 U | 0.07703 | 0.1389 | |
| Radium-226 (By Bismuth-214) | 1.074 | 0.1418 | 0.05836 | 0.2 |
| Thallium-208 | 0.4075 | 0.05989 | 0.02136 | |
| Thorium-232 (By Actinium-228) | 1.310 | 0.1716 | 0.07300 | 0.9 |
| Thorium-234 | 1.340 U | 1.023 | 1.564 | |
| Uranium-235 | 0.1813 | 0.2157 | 0.1710 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-009 | Received: | 12/20/13 |
| Lab ID: | 252048-009 | Prepared: | 12/26/13 08:10 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:04 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 324.04 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:35 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | 0.004559 U | 0.2166 | 0.1782 | 0.9 |
| Bismuth-212 | 1.364 | 0.4940 | 0.2214 | |
| Bismuth-214 | 0.8674 | 0.1269 | 0.05347 | |
| Cesium-137 | -0.008390 U | 0.03256 | 0.02610 | 0.07 |
| Cobalt-60 | 0.007044 U | 0.02816 | 0.02220 | 0.03 |
| Europium-152 | 0.02386 U | 0.07090 | 0.07462 | |
| Europium-154 | 0.03732 U | 0.08344 | 0.1359 | |
| Lead-212 | 1.087 | 0.1082 | 0.04787 | |
| Lead-214 | 1.028 | 0.1199 | 0.05806 | |
| Potassium-40 | 9.740 | 1.022 | 0.2614 | |
| Protactinium-234 | 0.01161 U | 0.06055 | 0.1125 | |
| Radium-226 (By Bismuth-214) | 0.8674 | 0.1269 | 0.05347 | 0.2 |
| Thallium-208 | 0.3338 | 0.05901 | 0.02553 | |
| Thorium-232 (By Actinium-228) | 1.408 | 0.2003 | 0.02719 | 0.9 |
| Thorium-234 | 1.264 U | 0.9239 | 1.552 | |
| Uranium-235 | 0.03714 U | 0.04184 | 0.1921 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-010 | Received: | 12/20/13 |
| Lab ID: | 252048-010 | Prepared: | 12/26/13 08:16 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:06 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 378.81 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:36 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | -0.1093 U | 0.2801 | 0.2271 | 0.9 |
| Bismuth-212 | 2.266 | 0.5898 | 0.2519 | |
| Bismuth-214 | 1.091 | 0.1292 | 0.05005 | |
| Cesium-137 | 0.006244 U | 0.03193 | 0.02583 | 0.07 |
| Cobalt-60 | -0.004609 U | 0.03015 | 0.02431 | 0.03 |
| Europium-152 | 0.02553 U | 0.03585 | 0.07680 | |
| Europium-154 | 0.05975 U | 0.1163 | 0.1435 | |
| Lead-212 | 1.504 | 0.1207 | 0.05692 | |
| Lead-214 | 1.235 | 0.1288 | 0.05377 | |
| Potassium-40 | 8.579 | 0.9144 | 0.2384 | |
| Protactinium-234 | 0.01298 U | 0.01933 | 0.1416 | |
| Radium-226 (By Bismuth-214) | 1.091 | 0.1292 | 0.05005 | 0.2 |
| Thallium-208 | 0.5581 | 0.06266 | 0.02063 | |
| Thorium-232 (By Actinium-228) | 1.744 | 0.1929 | 0.06782 | 0.9 |
| Thorium-234 | 1.633 U | 0.8628 | 1.801 | |
| Uranium-235 | 0.1050 U | 0.04898 | 0.2104 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-011 | Received: | 12/20/13 |
| Lab ID: | 252048-011 | Prepared: | 12/26/13 08:21 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:43 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 390.14 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:37 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | -0.05864 U | 0.2149 | 0.1750 | 0.9 |
| Bismuth-212 | 2.288 | 0.5196 | 0.2123 | |
| Bismuth-214 | 1.112 | 0.1235 | 0.04376 | |
| Cesium-137 | 0.01246 U | 0.03023 | 0.02396 | 0.07 |
| Cobalt-60 | -0.004916 U | 0.03012 | 0.02429 | 0.03 |
| Europium-152 | 0.08263 | 0.07222 | 0.06796 | |
| Europium-154 | 0.02148 U | 0.05518 | 0.1567 | |
| Lead-212 | 1.627 | 0.1157 | 0.04830 | |
| Lead-214 | 1.175 | 0.1301 | 0.05574 | |
| Potassium-40 | 8.121 | 0.8686 | 0.2511 | |
| Protactinium-234 | 0.06600 U | 0.07929 | 0.1319 | |
| Radium-226 (By Bismuth-214) | 1.112 | 0.1235 | 0.04376 | 0.2 |
| Thallium-208 | 0.4930 | 0.06344 | 0.02482 | |
| Thorium-232 (By Actinium-228) | 1.804 | 0.1649 | 0.07480 | 0.9 |
| Thorium-234 | 0.6132 U | 0.7532 | 1.481 | |
| Uranium-235 | 0.1354 U | 0.04796 | 0.1931 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-012 | Received: | 12/20/13 |
| Lab ID: | 252048-012 | Prepared: | 12/26/13 08:25 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:49 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 312.45 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:38 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|----------|---------|-------------|
| Americium-241 | 0.03489 U | 0.1951 | 0.1591 | 0.9 |
| Bismuth-212 | 1.764 | 0.5252 | 0.2086 | |
| Bismuth-214 | 0.9668 | 0.1439 | 0.05695 | |
| Cesium-137 | -0.006406 U | 0.03197 | 0.02574 | 0.07 |
| Cobalt-60 | -0.007496 U | 0.03374 | 0.02690 | 0.03 |
| Europium-152 | 0.002207 U | 0.007353 | 0.07175 | |
| Europium-154 | -0.01767 U | 0.2037 | 0.1657 | |
| Lead-212 | 1.338 | 0.1265 | 0.05907 | |
| Lead-214 | 1.289 | 0.1577 | 0.06771 | |
| Potassium-40 | 8.811 | 0.9473 | 0.2687 | |
| Protactinium-234 | 0.004443 U | 0.1571 | 0.1292 | |
| Radium-226 (By Bismuth-214) | 0.9668 | 0.1439 | 0.05695 | 0.2 |
| Thallium-208 | 0.4245 | 0.06616 | 0.02534 | |
| Thorium-232 (By Actinium-228) | 1.349 | 0.2080 | 0.07760 | 0.9 |
| Thorium-234 | 1.071 U | 0.8494 | 1.323 | |
| Uranium-235 | 0.1240 U | 0.04854 | 0.1921 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-013 | Received: | 12/20/13 |
| Lab ID: | 252048-013 | Prepared: | 12/26/13 08:30 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:50 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 332.98 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:39 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|----------|---------|-------------|
| Americium-241 | 0.1003 U | 0.2506 | 0.2023 | 0.9 |
| Bismuth-212 | 1.893 | 0.6168 | 0.2905 | |
| Bismuth-214 | 1.053 | 0.1328 | 0.05418 | |
| Cesium-137 | -0.005785 U | 0.03175 | 0.02566 | 0.07 |
| Cobalt-60 | -0.001709 U | 0.003153 | 0.02742 | 0.03 |
| Europium-152 | 0.05731 U | 0.06162 | 0.07401 | |
| Europium-154 | 0 U | 0.03939 | 0.1674 | |
| Lead-212 | 1.437 | 0.1298 | 0.06073 | |
| Lead-214 | 1.295 | 0.1360 | 0.05196 | |
| Potassium-40 | 8.372 | 0.9502 | 0.2605 | |
| Protactinium-234 | -0.01263 U | 0.03125 | 0.1402 | |
| Radium-226 (By Bismuth-214) | 1.053 | 0.1328 | 0.05418 | 0.2 |
| Thallium-208 | 0.4558 | 0.06548 | 0.02620 | |
| Thorium-232 (By Actinium-228) | 1.456 | 0.1847 | 0.09800 | 0.9 |
| Thorium-234 | 1.916 | 2.035 | 1.600 | |
| Uranium-235 | 0.09963 U | 0.04615 | 0.1713 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-014 | Received: | 12/20/13 |
| Lab ID: | 252048-014 | Prepared: | 12/26/13 08:35 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:52 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 344.53 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:40 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|---------|-------------|
| Americium-241 | 0.006243 U | 0.2710 | 0.2230 | 0.9 |
| Bismuth-212 | 1.780 | 0.4996 | 0.2106 | |
| Bismuth-214 | 0.9855 | 0.1205 | 0.04504 | |
| Cesium-137 | 0.00001229 U | 0.02885 | 0.02376 | 0.07 |
| Cobalt-60 | 0.005662 U | 0.02435 | 0.01919 | 0.03 |
| Europium-152 | 0.06359 U | 0.08581 | 0.06577 | |
| Europium-154 | -0.02464 U | 0.2266 | 0.1843 | |
| Lead-212 | 1.296 | 0.1094 | 0.04750 | |
| Lead-214 | 1.093 | 0.1110 | 0.04654 | |
| Potassium-40 | 9.011 | 0.9798 | 0.2707 | |
| Protactinium-234 | -0.08389 U | 0.1509 | 0.1213 | |
| Radium-226 (By Bismuth-214) | 0.9855 | 0.1205 | 0.04504 | 0.2 |
| Thallium-208 | 0.4503 | 0.06583 | 0.02540 | |
| Thorium-232 (By Actinium-228) | 1.565 | 0.1633 | 0.06925 | 0.9 |
| Thorium-234 | 0.9625 U | 0.7239 | 1.733 | |
| Uranium-235 | 0.07571 U | 0.06291 | 0.1985 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-015 | Received: | 12/20/13 |
| Lab ID: | 252048-015 | Prepared: | 12/26/13 08:41 |
| Matrix: | Soil | Analyzed: | 01/16/14 09:54 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 309.39 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:41 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|---------|-------------|
| Americium-241 | 0.0004365 U | 0.2495 | 0.2055 | 0.9 |
| Bismuth-212 | 1.783 | 0.5533 | 0.2374 | |
| Bismuth-214 | 0.9663 | 0.1296 | 0.04770 | |
| Cesium-137 | 0.01046 U | 0.03180 | 0.02521 | 0.07 |
| Cobalt-60 | 0.004400 U | 0.02239 | 0.02659 | 0.03 |
| Europium-152 | 0.02516 U | 0.04797 | 0.05649 | |
| Europium-154 | 0.006450 U | 0.02305 | 0.1623 | |
| Lead-212 | 1.126 | 0.1258 | 0.06315 | |
| Lead-214 | 1.077 | 0.1338 | 0.05786 | |
| Potassium-40 | 9.310 | 0.9887 | 0.2079 | |
| Protactinium-234 | -0.0007860 U | 0.1728 | 0.1423 | |
| Radium-226 (By Bismuth-214) | 0.9663 | 0.1296 | 0.04770 | 0.2 |
| Thallium-208 | 0.4209 | 0.06440 | 0.02405 | |
| Thorium-232 (By Actinium-228) | 1.445 | 0.2034 | 0.06111 | 0.9 |
| Thorium-234 | 1.716 U | 2.229 | 1.769 | |
| Uranium-235 | 0.1138 U | 0.04780 | 0.2262 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-016 | Received: | 12/20/13 |
| Lab ID: | 252048-016 | Prepared: | 12/26/13 08:46 |
| Matrix: | Soil | Analyzed: | 01/16/14 10:42 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 300.75 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:42 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|-------------|---------|---------|-------------|
| Americium-241 | -0.04852 U | 0.2450 | 0.2000 | 0.9 |
| Bismuth-212 | 1.661 | 0.6169 | 0.3141 | |
| Bismuth-214 | 1.103 | 0.1326 | 0.04166 | |
| Cesium-137 | 0.007342 U | 0.03178 | 0.02550 | 0.07 |
| Cobalt-60 | -0.003357 U | 0.03019 | 0.02440 | 0.03 |
| Europium-152 | 0.03368 U | 0.04894 | 0.07440 | |
| Europium-154 | 0.06202 U | 0.2012 | 0.1579 | |
| Lead-212 | 1.302 | 0.1226 | 0.05487 | |
| Lead-214 | 1.231 | 0.1472 | 0.06027 | |
| Potassium-40 | 9.852 | 1.020 | 0.2398 | |
| Protactinium-234 | -0.004888 U | 0.01018 | 0.1236 | |
| Radium-226 (By Bismuth-214) | 1.103 | 0.1326 | 0.04166 | 0.2 |
| Thallium-208 | 0.4041 | 0.06281 | 0.02586 | |
| Thorium-232 (By Actinium-228) | 1.286 | 0.1879 | 0.09901 | 0.9 |
| Thorium-234 | 1.405 U | 0.8863 | 1.650 | |
| Uranium-235 | 0.1035 U | 0.04628 | 0.2074 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-017 | Received: | 12/20/13 |
| Lab ID: | 252048-017 | Prepared: | 12/26/13 08:51 |
| Matrix: | Soil | Analyzed: | 01/16/14 10:45 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 324.13 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:43 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|------------|---------|---------|-------------|
| Americium-241 | 0.04146 U | 0.2113 | 0.1724 | 0.9 |
| Bismuth-212 | 1.942 | 0.6024 | 0.2781 | |
| Bismuth-214 | 1.381 | 0.1507 | 0.04986 | |
| Cesium-137 | -0.01216 U | 0.03796 | 0.03035 | 0.07 |
| Cobalt-60 | 0.004295 U | 0.01024 | 0.02646 | 0.03 |
| Europium-152 | 0.04840 U | 0.04137 | 0.07637 | |
| Europium-154 | -0.04248 U | 0.2310 | 0.1859 | |
| Lead-212 | 1.380 | 0.1416 | 0.07021 | |
| Lead-214 | 1.206 | 0.1360 | 0.05632 | |
| Potassium-40 | 8.276 | 0.9773 | 0.3298 | |
| Protactinium-234 | 0.01704 U | 0.06007 | 0.1272 | |
| Radium-226 (By Bismuth-214) | 1.381 | 0.1507 | 0.04986 | 0.2 |
| Thallium-208 | 0.4415 | 0.06821 | 0.02797 | |
| Thorium-232 (By Actinium-228) | 1.619 | 0.1851 | 0.09793 | 0.9 |
| Thorium-234 | 1.567 | 1.748 | 1.378 | |
| Uranium-235 | 0.1263 U | 0.04783 | 0.2123 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Gamma Radioactivity in Soil (Ingrowth)

| | | | |
|-----------|----------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-018 | Received: | 12/20/13 |
| Lab ID: | 252048-018 | Prepared: | 12/26/13 09:00 |
| Matrix: | Soil | Analyzed: | 01/16/14 10:46 |
| Units: | pCi/g | Duration (sec): | 2,700 |
| Basis: | dry | Sample Amount: | 331.97 g |
| Diln Fac: | 1.000 | Uncert. Sigma: | 2 |
| Batch#: | 206457 | Uncert. Units: | pCi/g |
| Sampled: | 12/20/13 10:44 | | |

| Analyte | Result | Uncert | MDA | Project MDA |
|-------------------------------|--------------|---------|---------|-------------|
| Americium-241 | -0.002152 U | 0.2519 | 0.2074 | 0.9 |
| Bismuth-212 | 1.838 | 0.5349 | 0.2385 | |
| Bismuth-214 | 1.177 | 0.1404 | 0.05311 | |
| Cesium-137 | -0.0004774 U | 0.02994 | 0.02462 | 0.07 |
| Cobalt-60 | -0.01029 U | 0.03104 | 0.02427 | 0.03 |
| Europium-152 | 0.01947 U | 0.06209 | 0.06780 | |
| Europium-154 | 0.01530 U | 0.07461 | 0.1625 | |
| Lead-212 | 1.405 | 0.1238 | 0.05556 | |
| Lead-214 | 1.290 | 0.1388 | 0.05269 | |
| Potassium-40 | 8.843 | 1.031 | 0.3180 | |
| Protactinium-234 | -0.02424 U | 0.1787 | 0.1464 | |
| Radium-226 (By Bismuth-214) | 1.177 | 0.1404 | 0.05311 | 0.2 |
| Thallium-208 | 0.4783 | 0.06420 | 0.02357 | |
| Thorium-232 (By Actinium-228) | 1.469 | 0.1814 | 0.08046 | 0.9 |
| Thorium-234 | 1.246 U | 0.7376 | 1.652 | |
| Uranium-235 | 0.1231 U | 0.04898 | 0.1971 | |

U= Not Detected

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

Batch QC Report

| Gamma Radioactivity in Soil (Ingrowth) | | | |
|--|---------------|-----------------|------------------------------|
| Lab #: | 252048 | Location: | Hunters Point Naval Shipyard |
| Client: | TetraTech | Prep: | GS 186/RA226 Prep |
| Project#: | 40440012 | Analysis: | DOE HASL 300 4.5.2.3 |
| Field ID: | 12A-TURAC-010 | Sampled: | 12/20/13 10:36 |
| Type: | IDUP | Received: | 12/20/13 |
| MSS Lab ID: | 252048-010 | Prepared: | 12/26/13 08:16 |
| Lab ID: | QC722918 | Analyzed: | 01/16/14 10:50 |
| Matrix: | Soil | Duration (sec): | 2,700 |
| Units: | pCi/g | Sample Amount: | 378.81 g |
| Basis: | dry | Uncert. Sigma: | 2 |
| Diln Fac: | 1.000 | Uncert. Units: | pCi/g |
| Batch#: | 206457 | | |

| Analyte | MSS Result | MSS TPU | Result | TPU | MDA | Project MDA | RPD | Lim | RER | Lim |
|-------------------------------|-------------|---------|--------------|----------|---------|-------------|--------|-----|---------|-----|
| Americium-241 | -0.1093 U | 0.2802 | -0.007107 U | 0.2742 | 0.2256 | 0.9 | NC | 40 | NC | 1 |
| Bismuth-212 | 2.266 | 0.6011 | 2.804 | 0.8043 | 0.3409 | | 21.25 | 40 | 0.3832 | 1 |
| Bismuth-214 | 1.091 | 0.1381 | 1.182 | 0.1372 | 0.04404 | | 8.078 | 40 | 0.3335 | 1 |
| Cesium-137 | 0.006244 U | 0.03193 | 0 U | 0.02256 | 0.03017 | 0.07 | NC | 40 | NC | 1 |
| Cobalt-60 | -0.004609 U | 0.03015 | 0 U | 0.004113 | 0.02622 | 0.03 | NC | 40 | NC | 1 |
| Europium-152 | 0.02553 U | 0.03587 | 0.009194 U | 0.01850 | 0.08310 | | NC | 40 | NC | 1 |
| Europium-154 | 0.05975 U | 0.1163 | 0.006288 U | 0.05892 | 0.1605 | | NC | 40 | NC | 1 |
| Lead-212 | 1.504 | 0.1625 | 1.467 | 0.1665 | 0.06150 | | 2.511 | 40 | 0.1134 | 1 |
| Lead-214 | 1.235 | 0.1411 | 1.179 | 0.1302 | 0.05046 | | 4.615 | 40 | 0.2053 | 1 |
| Potassium-40 | 8.579 | 1.011 | 8.537 | 0.9662 | 0.1893 | | 0.4849 | 40 | 0.02099 | 1 |
| Protactinium-234 | 0.01298 U | 0.01960 | -0.0006199 U | 0.1711 | 0.1409 | | NC | 40 | NC | 1 |
| Radium-226 (By Bismuth-214) | 1.091 | 0.1381 | 1.182 | 0.1372 | 0.04404 | 0.2 | 8.078 | 40 | 0.3335 | 1 |
| Thallium-208 | 0.5581 | 0.07212 | 0.5782 | 0.07286 | 0.01930 | | 3.550 | 40 | 0.1391 | 1 |
| Thorium-232 (By Actinium-228) | 1.744 | 0.2305 | 1.735 | 0.2249 | 0.07718 | 0.9 | 0.5347 | 40 | 0.02042 | 1 |
| Thorium-234 | 1.633 U | 0.8765 | 1.366 U | 0.8133 | 1.818 | | NC | 40 | NC | 1 |
| Uranium-235 | 0.1050 U | 0.04939 | 0.1365 U | 0.05540 | 0.2058 | | NC | 40 | NC | 1 |

U= Not Detected

NC= Not Calculated

MDA= estimate of the measured concentration that gives 99% confidence the analyte is present

RER= Relative Error Ratio

RPD= Relative Percent Difference

TPU= Total Propagated Uncertainty

Client Sample Results

Client: Tetra Tech, Inc.
Project/Site: Hunters Point Shipyard CTO12

TestAmerica Job ID: 160-5104-1
SDG: 160-5104

Method: 905.0 - Total Beta Strontium (GFPC)

Client Sample ID: 12A-TURAC-006

Date Collected: 12/20/13 10:32

Date Received: 01/09/14 11:10

Lab Sample ID: 160-5104-3

Matrix: Solid

| Analyte | Result | Qualifier | Count Uncert. (2σ+/-) | Total Uncert. (2σ+/-) | CRDL | MDL | Unit | Prepared | Analyzed | Dil Fac |
|----------------------|--------|-----------|-----------------------------|-----------------------------|-------|-------|-------|----------------|----------------|---------|
| Total Beta Strontium | 0.0132 | U | 0.199 | 0.199 | 0.320 | 0.163 | pCi/g | 01/16/14 13:41 | 01/21/14 19:07 | 1 |
| Carrier | %Yield | Qualifier | Limits | | | | | Prepared | Analyzed | Dil Fac |
| Sr Tracer | 84.2 | | 40 - 110 | | | | | 01/16/14 13:41 | 01/21/14 19:07 | 1 |

TestAmerica St. Louis

Client Sample Results

Client: Tetra Tech, Inc.
Project/Site: Hunters Point Shipyard CTO12

TestAmerica Job ID: 160-5104-1
SDG: 160-5104

Method: 905.0 - Total Beta Strontium (GFPC)

Client Sample ID: 12A-TURAC-017

Date Collected: 12/20/13 10:43

Date Received: 01/09/14 11:10

Lab Sample ID: 160-5104-4

Matrix: Solid

| Analyte | Result | Qualifier | Count Uncert. (2σ+/-) | Total Uncert. (2σ+/-) | CRDL | MDL | Unit | Prepared | Analyzed | Dil Fac |
|----------------------|--------|-----------|-----------------------------|-----------------------------|-------|-------|-------|----------------|----------------|---------|
| Total Beta Strontium | -0.130 | U | 0.166 | 0.166 | 0.320 | 0.144 | pCi/g | 01/16/14 13:41 | 01/21/14 19:08 | 1 |
| Carrier | %Yield | Qualifier | Limits | | | | | Prepared | Analyzed | Dil Fac |
| Sr Tracer | 83.7 | | 40 - 110 | | | | | 01/16/14 13:41 | 01/21/14 19:08 | 1 |

TestAmerica St. Louis

Client Sample Results

Client: Tetra Tech, Inc.
Project/Site: Hunters Point Shipyard CTO12

TestAmerica Job ID: 160-5104-1
SDG: 160-5104

Method: A-01-R - Isotopic Plutonium (Alpha Spectrometry)

Client Sample ID: 12A-TURAC-002

Date Collected: 12/20/13 10:27

Date Received: 01/09/14 11:10

Lab Sample ID: 160-5104-1

Matrix: Solid

| Analyte | Result | Qualifier | Count Uncert. (2σ+/-) | Total Uncert. (2σ+/-) | CRDL | MDL | Unit | Prepared | Analyzed | Dil Fac |
|-------------------|----------|-----------|-----------------------------|-----------------------------|------|--------|-------|----------------|----------------|---------|
| Plutonium-238 | -0.00563 | U | 0.0383 | 0.0383 | 1.00 | 0.0339 | pCi/g | 01/17/14 09:45 | 01/22/14 16:55 | 1 |
| Plutonium-239/240 | -0.00563 | U | 0.00650 | 0.00651 | 1.00 | 0.0134 | pCi/g | 01/17/14 09:45 | 01/22/14 16:55 | 1 |
| Tracer | %Yield | Qualifier | Limits | | | | | Prepared | Analyzed | Dil Fac |
| Pu-242 (T) | 93.9 | | 30 - 110 | | | | | 01/17/14 09:45 | 01/22/14 16:55 | 1 |

TestAmerica St. Louis

Client Sample Results

Client: Tetra Tech, Inc.
Project/Site: Hunters Point Shipyard CTO12

TestAmerica Job ID: 160-5104-1
SDG: 160-5104

Method: A-01-R - Isotopic Plutonium (Alpha Spectrometry)

Client Sample ID: 12A-TURAC-005

Date Collected: 12/20/13 10:31

Date Received: 01/09/14 11:10

Lab Sample ID: 160-5104-2

Matrix: Solid

| Analyte | Result | Qualifier | Count | Total | CRDL | MDL | Unit | Prepared | Analyzed | Dil Fac |
|-------------------|---------|-----------|----------|---------|------|--------|-------|----------------|----------------|---------|
| | | | Uncert. | Uncert. | | | | | | |
| | | | (2σ+/-) | (2σ+/-) | | | | | | |
| Plutonium-238 | 0.0180 | U | 0.0384 | 0.0385 | 1.00 | 0.0219 | pCi/g | 01/17/14 09:45 | 01/22/14 16:55 | 1 |
| Plutonium-239/240 | 0.00467 | U | 0.0224 | 0.0224 | 1.00 | 0.0143 | pCi/g | 01/17/14 09:45 | 01/22/14 16:55 | 1 |
| | | | | | | | | | | |
| Tracer | %Yield | Qualifier | Limits | | | | | Prepared | Analyzed | Dil Fac |
| Pu-242 (T) | 88.0 | | 30 - 110 | | | | | 01/17/14 09:45 | 01/22/14 16:55 | 1 |

TestAmerica St. Louis

APPENDIX A

GEOLOGICAL ANALYSIS OF ELEVATED CONCENTRATIONS OF NATURALLY OCCURRING RADIOACTIVE MATERIAL IN HUNTERS POINT NAVAL SHIPYARD PARCEL C FILL MATERIAL

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Geological Analysis of Elevated Concentrations of Naturally Occurring Radioactive Material in Hunters Point Naval Shipyard Parcel C Fill Material

Introduction

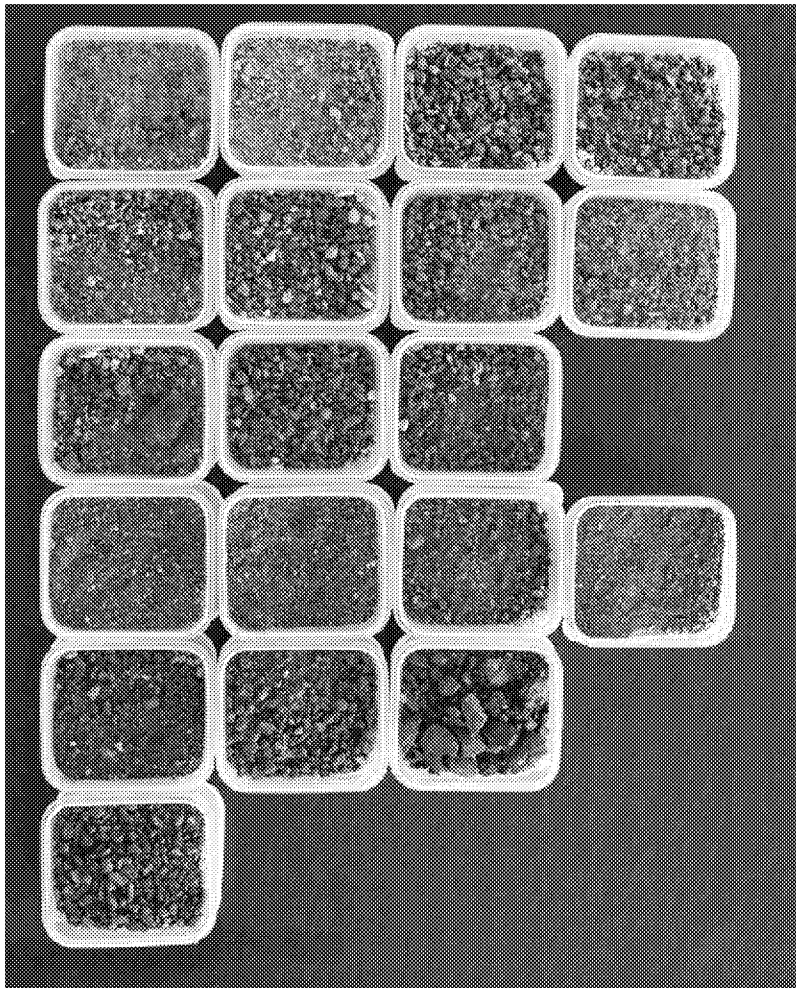
During the wartime expansion of Hunters Point Naval Shipyard (HPNS), the Navy moved vast quantities of soil to create the footprint of HPNS as it exists today. Most of Parcel C was constructed by placing borrowed fill material either outboard of the shoreline to create additional land surface or to bring the existing lowlands up to grade. While there is no clear documentation, the likely source of the backfill material was the upland area of HPNS which was graded contemporaneous with the infilling of Parcel C as evidenced in historic photos, an example of which is provided in Figure 1.

As mapped by the United States Geological Survey (USGS), the upland portion of HPNS consists of a combination of Franciscan Formation fringed by Quaternary silty sands and clays and alluvial fill. Figure 1 includes the relevant portion from 1998 Preliminary Geologic Map of the San Francisco South 7.5' Quadrangle and Part of the Hunters Point 7.5' Quadrangle, San Francisco Bay Area, California (Bonilla 1998) in respect to Parcel C. See Attachment 1 for a generalized description of Franciscan-related rocks: serpentine, basalt, chert, and interbedded sandstones and shales. Franciscan soils, especially those derived from serpentine rocks, are typically dark greenish gray to bluish gray in color and are low in potassium and calcium and high in chromium, magnesium, and nickel.

Figure 2 shows the Parcel C storm drain and sanitary sewer trenches excavated for radiological remediation and shows the approximate location of the 1935 shoreline. The near surface (less than 10 feet below ground surface) artificial fill lithologies, as described in boring logs from monitoring wells in the area, are varied and range from dark gray serpentinite sands, clays, and gravels to yellowish brown clayey sands with serpentinite gravels. The presence of the serpentinite sands and gravels in near surface soils are consistent with an upland source of backfill.

Description of Franciscan-derived Soils Encountered in Parcel C Trenches

Survey Unit (SU) 326 from Parcel C provides an example of the variety of soil types and colors frequently encountered as backfill at Parcel C. A photograph of samples collected from the trench is included as Photograph 1. The lithologies of the samples collected from SU326 range from light greenish gray (GLEY1 7/1) angular coarse sands with bluish green lithic fragments and volcanic fragments with minor iron oxide staining to yellowish brown coarse angular sands with gray and brown lithic and volcanic fragments to fine gravels of gray sandstone likely derived from Franciscan gray sandstone (greywacke) with silt.



Photograph 1. Range of Franciscan-derived fill from SU 326

Extent, Description, and Radiological Characteristics of Fill Sand

While most of the trenches at Parcel C consisted of a patchwork of Franciscan-derived backfill similar to that described above in SU326, a fine-grained contiguous yellowish-brown sand has been encountered at select trench locations adjacent to, and just beneath roadways, and along utility conduits at other locations in Parcel C (see Photograph 2). Trenches where the fill sand was encountered are shown on Figure 1 of the main document. The sand is yellowish to reddish brown, occurs in contiguous layers, and stands out in contrast with the patchwork of typical greens and grays of the Franciscan-derived backfill.

The sand is fine grained and poorly sorted with well-rounded grains of quartz, miscellaneous lithic fragments, and abundant magnetite as examined using a hand lens. No man-made material, such as paint chips or sandblast grit is present. When analyzed via gamma spectroscopy, the sand reports elevated radium-226 (Ra-226) concentrations in the range of 0.9 to 1.3 picocuries per gram (pCi/g).



Photograph 2. Fill sand exposed in trench at Parcel C.

Correlation to Colma Formation

The fill sand found along the roadways and utility corridors at Parcel C is very similar in physical appearance to fill derived from the non-Franciscan Colma Formation which was encountered during excavation activities at Building 518, an area considered to be non-radiologically impacted. Based on petrographic analysis, the elevated radium-226 (Ra-226) concentrations (1.5 to 2.1 pCi/g) found in the fill at Building 518 have been attributed to the presence of NORM (TtEC, 2013).

The Colma Formation, shown in Photograph 3, is generally comprised of poorly consolidated yellowish or reddish brown sands with occasional occurrences of oxidized sand with heavy mineral laminations (Schlocker 1974). The environment of deposition for the Colma is wide-ranging – interpreted as various beach environments (Caskey 2005). Because the environment of deposition is wide-ranging and the underlying formation differs (either Franciscan or Merced Fm), the actual composition of the Colma is variable – containing everything from re-worked Franciscan Formation, Sierran detritus carried by an ancient river that drained through San Francisco Bay during times of low sea level, and reworked Merced Fm.



Photograph 3. Colma Formation exposed along the cliffs at Fort Funston.

There is no published data on background radiologic concentrations for the Colma Formation. As part of the Building 518 investigation, a series of sand samples were collected from the top of the Colma to the base of the Merced exposed along the cliffs at Fort Funston and analyzed via gamma spectroscopy. Results are shown in the table below.

Table 1 – Colma/Merced Formation Gamma Spectroscopy Results

| Sample ID | Bi-214 (pCi/g) | Pb-214 (pCi/g) | Ra-226 (pCi/g) | Ac-228 (pCi/g) |
|---------------|-------------------|-------------------|-------------------|-------------------|
| 04A-FUNST-001 | 1.1650 | 1.3190 | 1.9030 | 1.6420 |
| 04A-FUNST-002 | 0.4455 | 0.5622 | 0.1968 | 1.0710 |
| 04A-FUNST-003 | 1.0840 | 1.1290 | 1.3340 | 1.4760 |
| 04A-FUNST-004 | 0.8673 | 1.0850 | 1.3840 | 1.3820 |
| 04A-FUNST-005 | 0.9753 | 1.1400 | 0.8795 | 1.5050 |
| 04A-FUNST-006 | 2.5340 | 2.6730 | 3.5650 | 3.8910 |

Of these samples, the sample collected from the lower portion of the Colma Formation, midway down the cliff exposure at Fort Funston, 04A-FUNST-003, most closely matches the gamma results from observed in the Parcel C fill sand. This sample was additionally sent on for analysis of isotopic thorium, isotopic uranium, and isotopic plutonium. The results and comparison to the Parcel C utility sand are discussed Section 3.4 of the main document.

Conclusion

The fine-grained yellowish-brown flowing sand encountered in trenches in Parcel C is very similar in color, lithology, and radiologic characteristics to fill material derived from the Colma Formation. Petrographic analysis of similar fill material encountered at HPNS (Building 518) attributed the elevated gamma results to NORM, which was present in the samples in the form of zircon.

REFERENCES

- Bonilla, M.G. 1998. Preliminary Geologic Map of the San Francisco South 7.5' Quadrangle and Part of the Hunters Point 7.5' Quadrangle, San Francisco Bay Area, California. USGS (United States Geological Survey). Open File Report 98-354.
- Caskey, S.J., K. Grove, C. Li, and G.W. Berger. 2005. Constraints on Late Pleistocene and active uplift rates along the Sierra Fault and the timing of late Pleistocene transpressional deformation along the San Andreas Fault, Northern San Francisco Peninsula. USGS.
- Schlocker, J. 1974. Geology of the San Francisco North Quadrangle, California. Geological Survey Professional Paper 782. United States Government Printing Office.
- Tetra Tech, EC, Inc. 2012. Recommendation for Disposal or Reuse of Building 518 Backfill Sand (letter report). December.

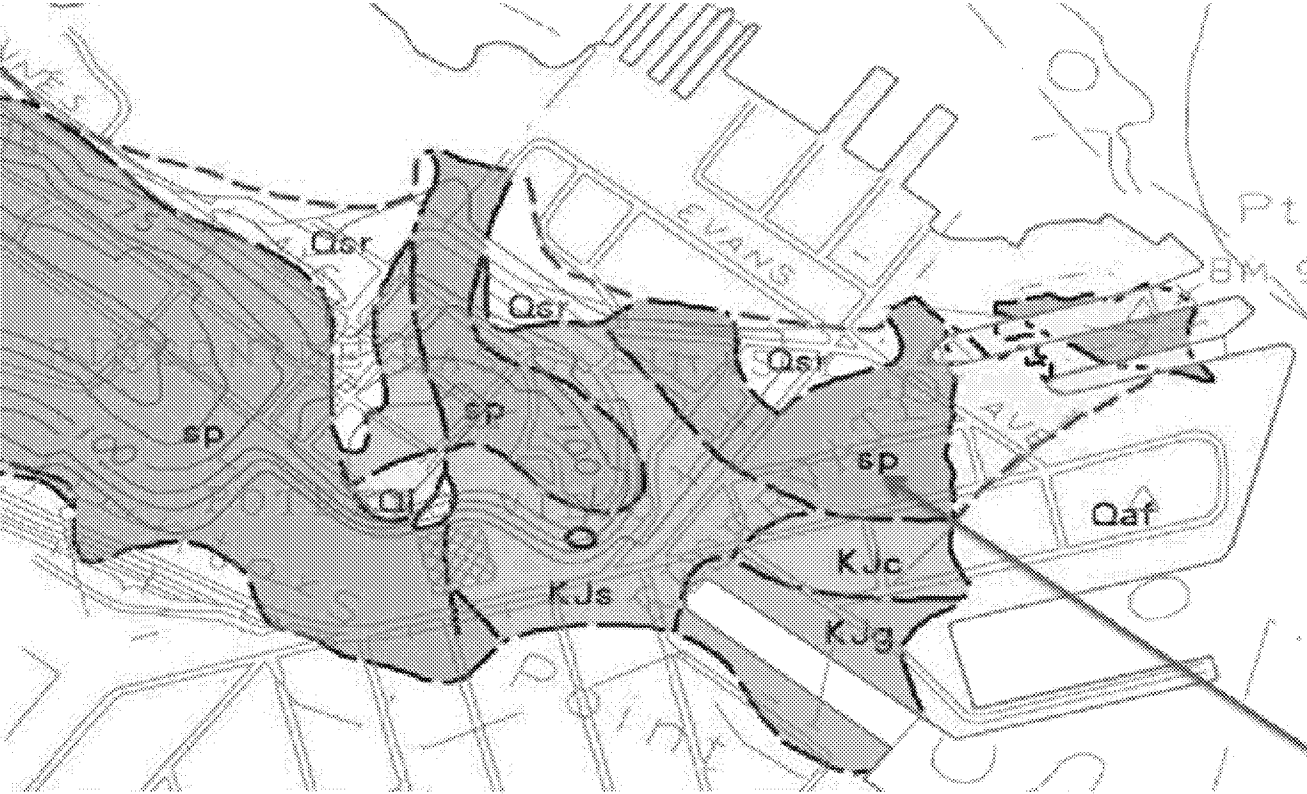
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FIGURES





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


Bonilla, M.G., 1998. Preliminary Geologic Map of the San Francisco South 7.5' Quadrangle and Part of the Hunters Point 7.5' Quadrangle, San Francisco Bay Area, California.



Note the Navy's grading (cut) and movement of the Franciscan Formation including serpentine, Chert, and altered volcanic, and sandstone material on the hill to expand HPS.

-  **sp** Serpentine
Hard to soft, generally greenish gray; contains small bodies of gabbro and diabase.
-  **Qaf** Artificial fill
Clay, silt, sand, rock fragments, organic matter, and man-made debris.
-  **KJc** Chert
Hard chert interbedded with firm shale; chert layers generally two or three inches thick, shale layers less than one inch thick; generally grayish red.
-  **KJg** Greenstone
Altered volcanic rocks, fine grained, mostly basalt; hard where fresh, but weathered and firm to soft in most exposures; commonly grayish olive to moderate olive gray where moderately weathered, dark yellowish orange to light brown where highly weathered.

-  **KJs** Sandstone and shale
Interbedded sandstone and shale, hard where fresh and intact, soft where weathered or sheared. Commonly medium dark gray where fresh, olive gray to yellowish brown where moderately weathered, and yellowish orange to yellowish gray where highly weathered.
-  **Ql** Landslide deposits
Composition and structure depend on the geologic formation involved and type of landslide.
-  **Qsr** Slope debris and ravine fill
Stony silty to sandy clay, locally silty to clayey sand or gravel; yellowish-orange to medium gray, unstratified or poorly stratified. Where it overlies the Merced or Colma Formation it is commonly a silty to clayey sand, or gravel.

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

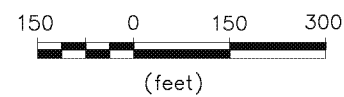
FIGURE 1
HISTORICAL PARCEL C
CONSTRUCTION AND GEOLOGIC MAP

HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA

REVISION: —
AUTHOR: A.CRABTREE
PROJECT NO:
FILE: SEE BELOW



TETRA TECH EC, INC.



ATTACHMENT 1

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Serpentinite

Pillow Basalt

Ribbon Chert

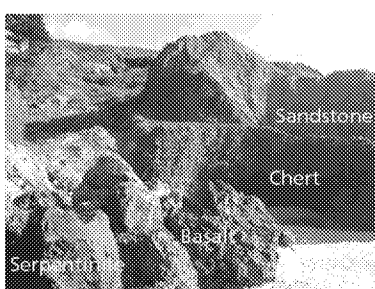
Graywacke Sandstone

Franciscan Rocks of the Marin Headlands Terrane

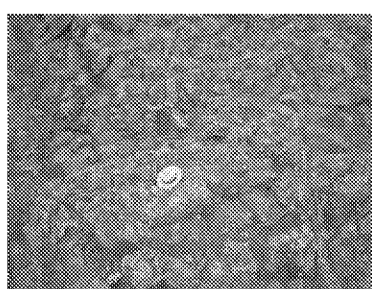


Introduction

The Marin Headlands Terrane contains rock types typical of the Franciscan Complex including the following: 1) sedimentary sandstone and shale (deposited by submarine landslides along the continental margin), 2) oceanic basalt (erupted from underwater volcanoes and commonly altered to a rock called greenstone), 3) ribbon chert (made of the silica-rich shells of single-celled Radiolaria), and 4) serpentinite (formed from altered upper mantle rock). Limestone and several metamorphic rock types, like blueschist (produced under high-pressures), amphibolite and eclogite (formed under high-temperatures) also are present in smaller amounts.



Melange containing four main Franciscan rock types. Marin Headlands Terrane at Baker Beach at the Presidio.

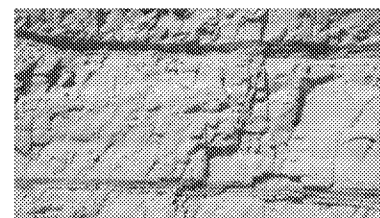


Pillow basalt with red chert beds at Point Bonita. Chert layers were deposited at times of volcanic quiescence.

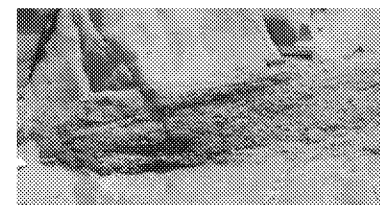
Sandstone and Shale

Sandstone is the most common clastic rock in the Marin Headlands Terrane. It is made of a mixture of angular feldspar, quartz, and volcanic rock fragments. The volcanic fragments give the sandstone a greenish-gray color and hence its common name, graywacke. These rocks were deposited by submarine landslides, called turbidites, that slid off the continental margin and flowed into the deep trench developed at the subduction zone.

The sandstone beds are mostly 1-2 m (3-6 feet) thick but can reach over 20 m (66 feet) in thickness. The beds may have cobbles or pebbles at their bases and contain progressively finer sandstone, silt and shale particles upwards. This progression results from decreasing transport energy after slide events. As the energy decreased, smaller and smaller particles dropped out of suspension and were deposited.



The thin dark layers separating sandstone beds reflect the slow deposition of mud between the slide events.



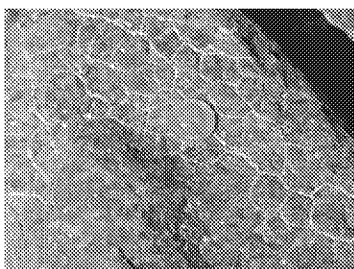
Carbonized plant material is sometimes concentrated at the tops of sandstone beds, perhaps floating to the top of the saupy sand soon after a turbidite event.

Serpentinite

Serpentinite, the California State Rock, is made of serpentine-group minerals, which include chrysotile (asbestos), lizardite, and antigorite. These minerals give a blue-green color to serpentinite blocks and the clay zones that surround them. In outcrop, rounded serpentinite blocks, typically 1 to 2 m (3 to 6 feet) in diameter, are surrounded by sheared, flaky serpentine called slickentite.

Serpentinite in the Franciscan Complex is made of fragments of oceanic crust and mantle (ophiolite) that were plastered onto the margin of North America rather than being subducted under it. Hot fluids flowing through the subduction zone altered the iron- and magnesium-rich minerals of these rocks to serpentine, making the rocks lighter and more easily deformed.

Because serpentinite is altered mantle rock, its chemistry is unlike other continental rocks. Serpentinite is low in potassium and calcium, which are important plant nutrients. It also contains high levels of magnesium, nickel and chromium that can be toxic to plants. Therefore, plants living on serpentine soils are specially adapted to these unusual chemical conditions and some species only grow at one or a few outcrop areas. Many of the rare plant species in the Golden Gate National Recreation Area are specially adapted to serpentine soils.



Serpentinite block showing shiny relict crystal textures (basaltic replacements of pyroxene crystals) and a lacy network of 1-2 mm asbestos veins.



Rounded pillow structures in basalt altered to greenstone at Point Bonita. Pillows form in underwater volcanic flows.

Oceanic Basalt

The chemistry of basalt in the Marin Headlands Terrane indicates that it was erupted from mid-ocean ridge volcano. Hot sea water at the eruption site changed minerals in the basalt to chlorite and pumpellyite, giving it a dark green color and hence the name, greenstone.

Most basalt of the Marin Headlands Terrane exhibits rounded forms shaped like pillows and is known as pillow basalt. Most pillows are less than a meter across (3 feet) and have rounded tops and downward projecting keels molded by the tops of the older underlying pillows. These forms show which direction was originally up and demonstrate an underwater origin for the flows.

At some places sedimentary chert lies between the pillows. At other places pelagic limestone is present between pillow forms. The occurrence of these slowly-deposited sedimentary rocks indicates periods of volcanic quiescence between eruptions.

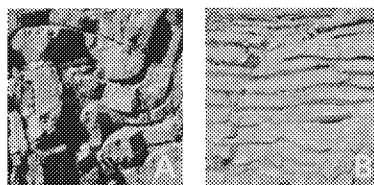
The presence of limestone indicates that the eruption site was above carbonate compensation depth (CCD - the depth below which all carbonate material dissolves in sea water), which is around 4 km (2.4 miles) deep in today's oceans. The lack of limestone in the chert layers above shows that the oceanic plate quickly descended below CCD.

Chert

Chert of the Marin Headlands Terrane contains abundant fossil radiolaria. The tiny silica shells of these single cell organisms are smaller than a grain of sand but can be seen clearly with a hand magnifier. At most places, thin red chert layers alternate with thinner, dark red shale beds. The red color indicates that the iron in the rock is oxidized. Some green to white chert beds also are present. Because of the thin bedding, these rocks are commonly called ribbon chert. Chert deposited near the pillow basalts (at the base of the sedimentary rock sequence) is stained black by manganese oxide that precipitated from manganese-rich waters circulating near the volcano.

Locally, the chert is intensely folded. Most likely, this folding occurred when the rocks were wedged against the continental margin and faulted to their present position. However, abrupt changes from only slightly to highly folded areas and unbroken sharply folded beds suggest that some of the contorted folding reflects submarine slumping prior to the muddy ooze becoming hard rock.

The rhythmic bedding of the chert is one of its most distinguishing features. The contrast between hard chert beds and intervening shale beds was increased as silica moved from less silica-rich zones to more silica-rich beds during burial and transformation of the mud into chert.



Ribbon chert on Conzelman Road in the Marin Headlands. A) Tight folds lacking fractures suggest the folding occurred before the sediments were hard. B) Migration of silica from clay-rich intervals into silica-rich zones enhanced the chert beds, making them look ribbon-like.

Where You Can See These Rocks

